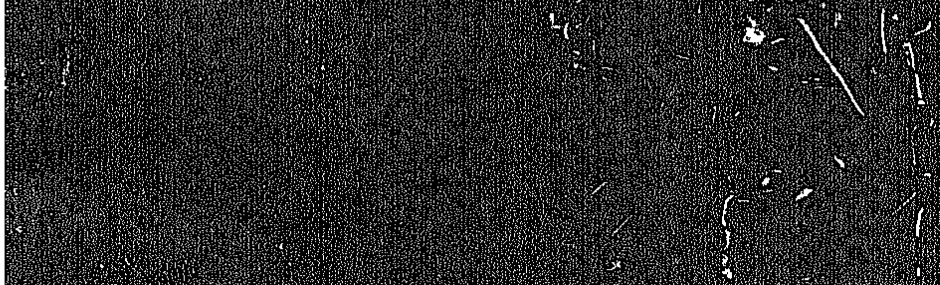
U.S. Department of Housing and Urban Development

A COMPENDIUM OF BUILDING CONCEPTS

2

VOLUME



OPERATION BREAKTHROUGH

U.S. Department of Housing and Urban Development

A COMPENDIUM OF BUILDING CONCEPTS

VOLUME 2

contents

introduction

The Department of Housing and Urban Development initiated Operation BREAKTHROUGH in May 1969 to demonstrate the use of factory-produced housing components in meeting the housing needs of all income groups. One of the important tasks for HUD under this program was to create the environment necessary for private industry to develop new concepts and techniques for designing and constructing housing.

This Compendium describes some of those innovative concepts and techniques which have been developed and utilized by the Housing Systems Producers selected by HUD to participate in the program. These concepts and techniques have been arranged in this Compendium under nine major building element classifications for easy identification.

It is hoped that this Compendium will prove useful to the homebuilders, home designers, building researchers, product manufacturers and industry managers working in today's market, as well as to all persons interested in improving the quality and delivery of housing across the nation. The Compendium is provided as a source of information only and does not constitute endorsement by HUD of any concept listed.

Michael H. Moskow
Assistant Secretary for Policy
Development and Research

BUILDING ELEMENTS

1. ENCLOSED SPACES

Those spaces produced as a result of arranging the living unit into discrete areas by the use of interior enclosures.

2. STRUCTURE

That portion of the building system which supports or transmits dead and live loads.

3. EXTERIOR ENCLOSURE

That part of the building system which separates the interior spaces from the exterior environment.

4. INTERIOR ENCLOSURE

That part of the building system which separates the spaces within a building and not exposed to the exterior environment.

5. HEATING, VENTILATING AND AIR CONDITIONING

That system and equipment for producing the required conditions in the building with respect to temperature, humidity, air movement and air quality.

6. PLUMBING

That system and equipment for the supply of water and gas and the removal of liquid-borne waste products.

7. ELECTRICAL

That system and equipment for the supply and distribution of electricity within the building.

8. ELEVATORS

That system and equipment for vertical transportation.

9. HARDWARE, SPECIALTIES AND APPLIANCES

Those manufactured products and equipment which are incorporated in the building system such as locks, hinges, mail handling facilities, communication and trash removal as well as pre-assembled manufactured products which support human activity such as food preparation and storage, laundering and food waste disposal.

1.

ENCLOSED SPACES

1.2 OPEN STACKED MODULE CREATES EXTRA SPACE

Housing Manufacturer: Shelley

Precast concrete box modules are stacked alternately one upon another to form a checkerboard pattern—Figure 1.2a.

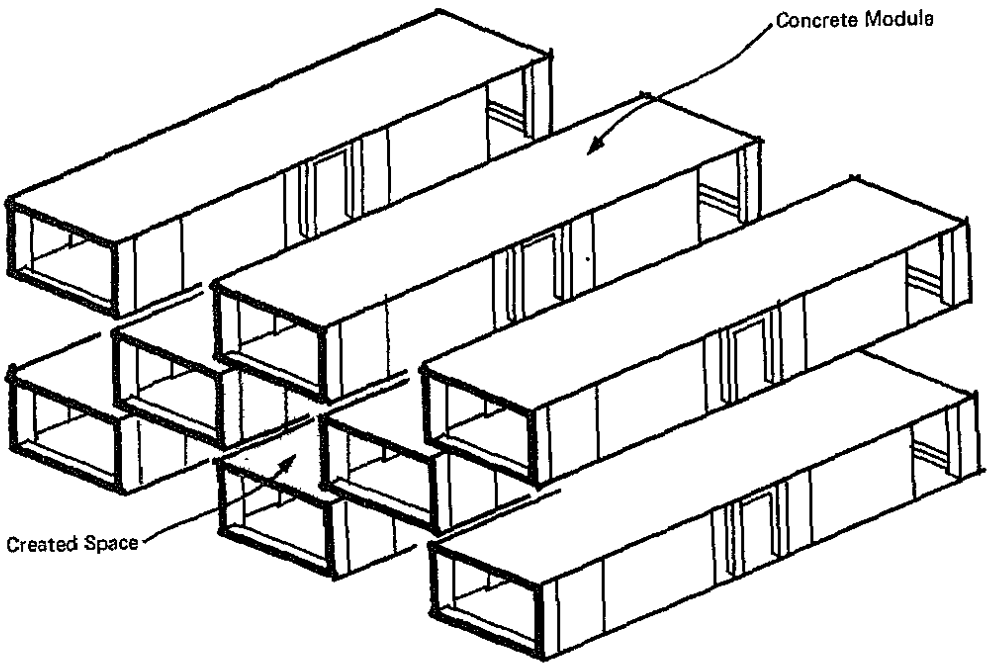


FIGURE 1.2a
CHECKERBOARD ARRANGEMENT OF MODULES

1.2 OPEN STACKED MODULE CREATES EXTRA SPACE
continued

The open spaces created become usable living areas. Precast roof closure panels, floor closure panels and end wall closure panels are used to seal off the created space—Figure 1.2b.

Each concrete module which is poured monolithically in the factory consists of a floor slab, a roof slab, side walls, columns and partition walls. Load-bearing columns are an integral part of the module. When the modules are stacked, these columns match vertically, carrying gravity loads to the foundation.

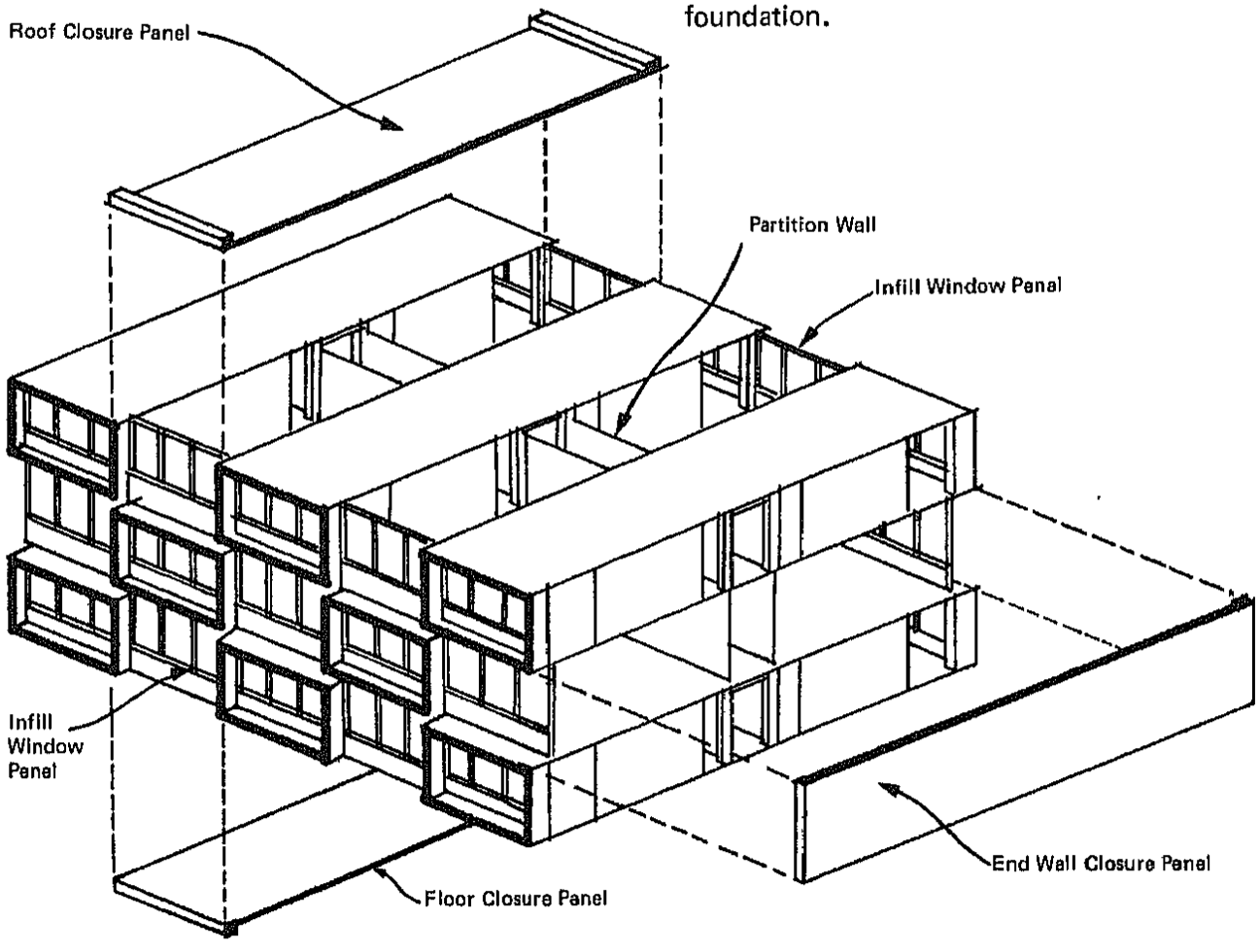


FIGURE 1.2b
COMPLETION OF STRUCTURAL ASSEMBLY

1.3 EXTRA HALL SPACE CREATED BETWEEN BOX MODULES

Housing Manufacturer:
Home Building Corporation

Many modular housing systems are built in two or more sections which are brought together and joined in the field—Figure 1.3a. Because modules are limited in widths due to transportation constraints, hallways take from the space which could be used for other living areas.

In the Home Building system a hall is assembled between modules on the site from precut and prefinished components—Figure 1.3b. This allows the rooms to retain their maximum possible dimension. In addition, this erection procedure makes it easier to align the modules to the required tolerances since they do not have a common interface.

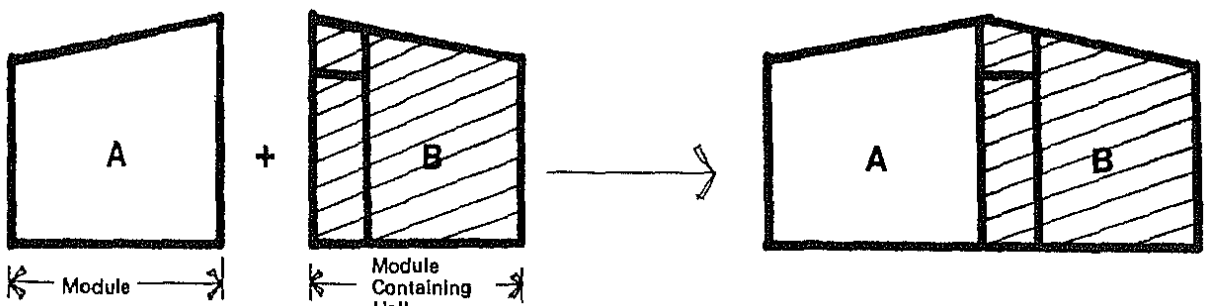


FIGURE 1.3a
HALLWAY TAKES FROM OTHER LIVING SPACE

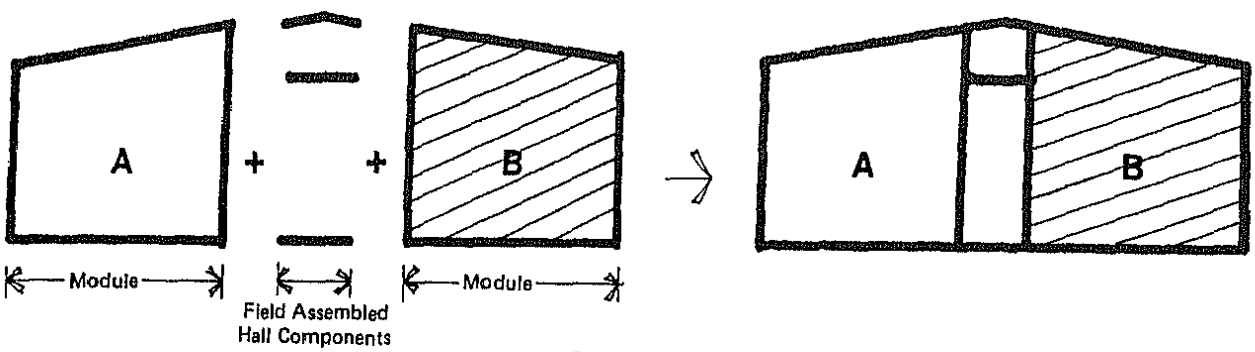


FIGURE 1.3b
SITE ASSEMBLED HALLWAY BETWEEN MODULES

1.4 SPACE SAVING FLOOR/ CEILING ASSEMBLY

Housing Manufacturer:
Home Building Corporation

The typical floor/ceiling assembly in modular construction provides improved acoustical control in multi-family dwellings. As shown in Figures 1.4a and 1.4b, the floor platform of the upper module and the ceiling of the lower module have joist systems which are separated by an air space, resulting in a decrease in sound transmission through the structure. However, in most systems this has the disadvantage of a deep floor/ceiling assembly.

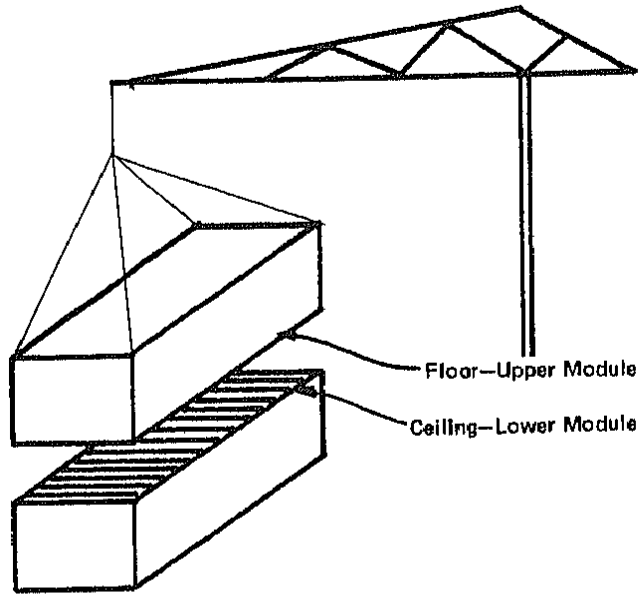


FIGURE 1.4a
ERECTION OF MODULES

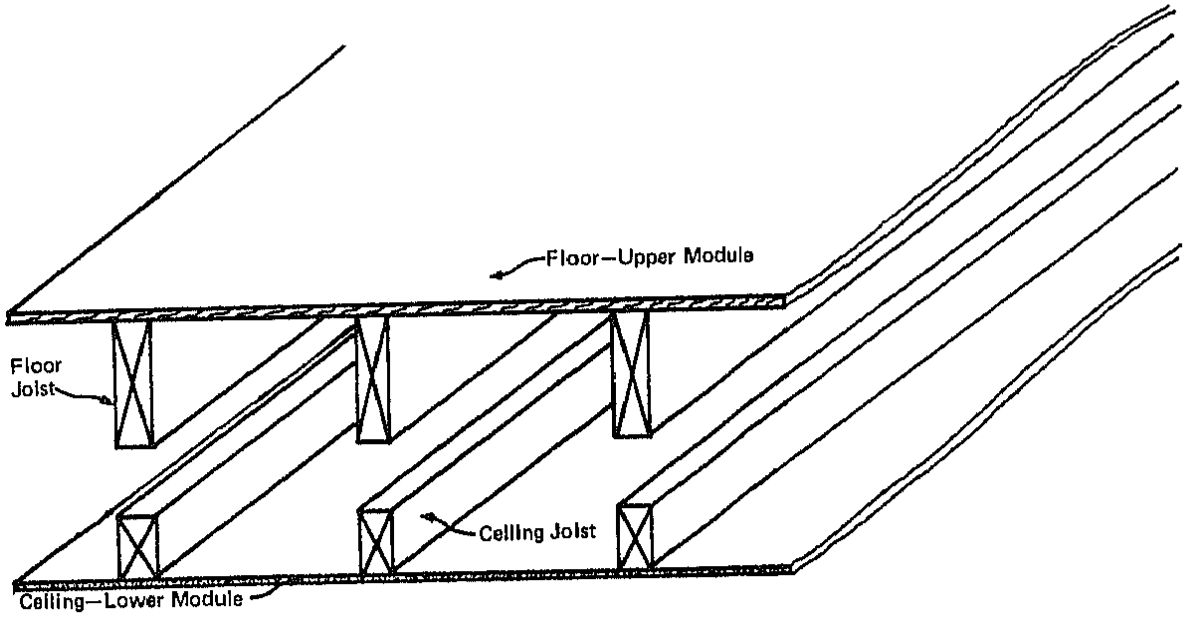


FIGURE 1.4b
CONVENTIONAL FLOOR/CEILING ASSEMBLY

1.4 SPACE SAVING FLOOR/ CEILING ASSEMBLY
continued

Home Building Corporation constructs a floor/ceiling assembly using off-centered joists, which results in a decrease in the depth of the assembly while retaining improved sound isolation since the joists do not touch –Figure 1.4c.

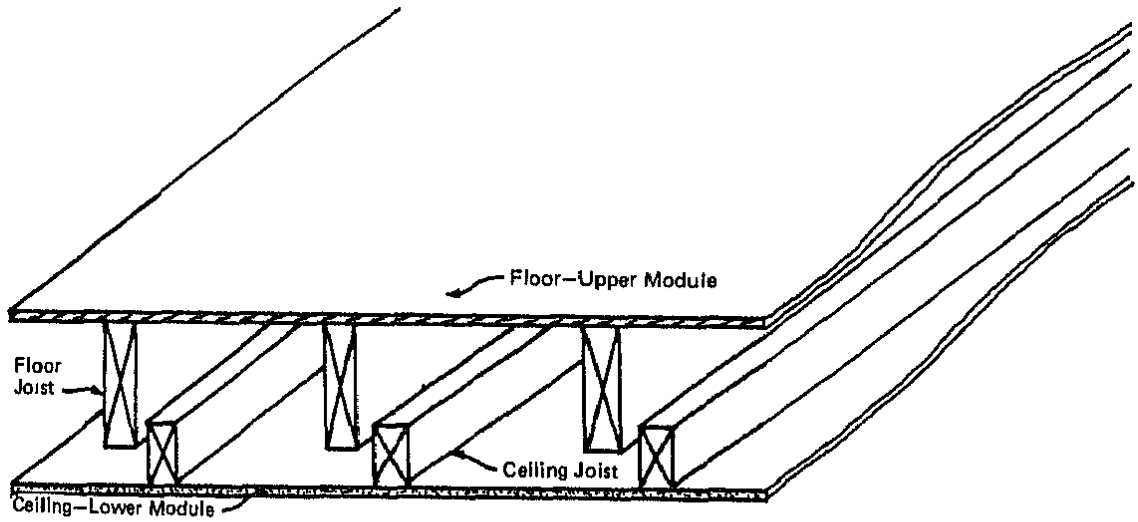


FIGURE 1.4c
OFF-CENTERED JOISTS FLOOR/CEILING ASSEMBLY

1.5 BATHROOM PLANNING FOR THE ELDERLY

Housing Manufacturer:
FCE-Dillon

The FCE-Dillon high-rise apartment buildings for the elderly contain alternative floor plans for single bedroom units in an attempt to evaluate occupant preference.

Floor plan A has a bathroom with access from the living room through an alcove—Figure 1.5a. This has the advantage of not disturbing persons in the bedroom when the bathroom is used, but the disadvantage of decreasing floor area in the bedroom.

Floor plan B has a bathroom with access only through the bedroom—Figure 1.5b. In this case, privacy in the bedroom is sacrificed for more floor area.

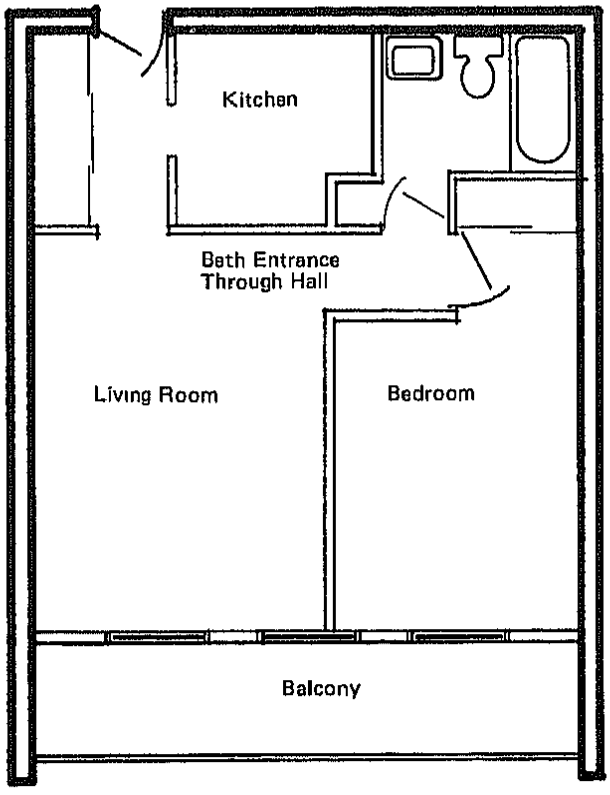


FIGURE I.5a
FLOOR PLAN A

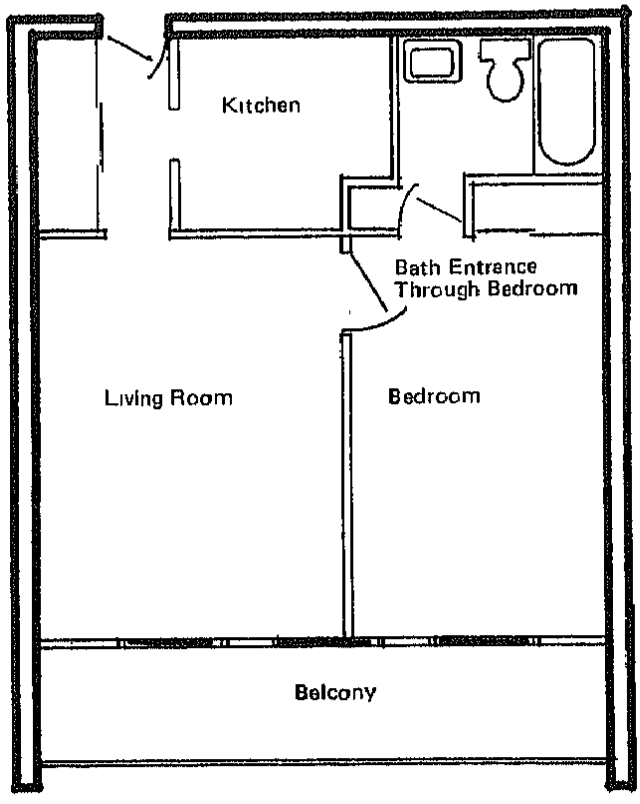


FIGURE I.5b
FLOOR PLAN B

1.6 TWO-STORY MAISONETTES

Housing Manufacturer:
Descon/Concordia

In multi-story design the corridor that occurs every floor uses space and blocks cross-building apartments that can catch the breeze and provide a view from two directions.

The two-story maisonette apartment arrangement overcomes these disadvantages by having access corridors every other floor. The corridor space that is eliminated is provided to tenants in the form of extra living space in the dwelling units.

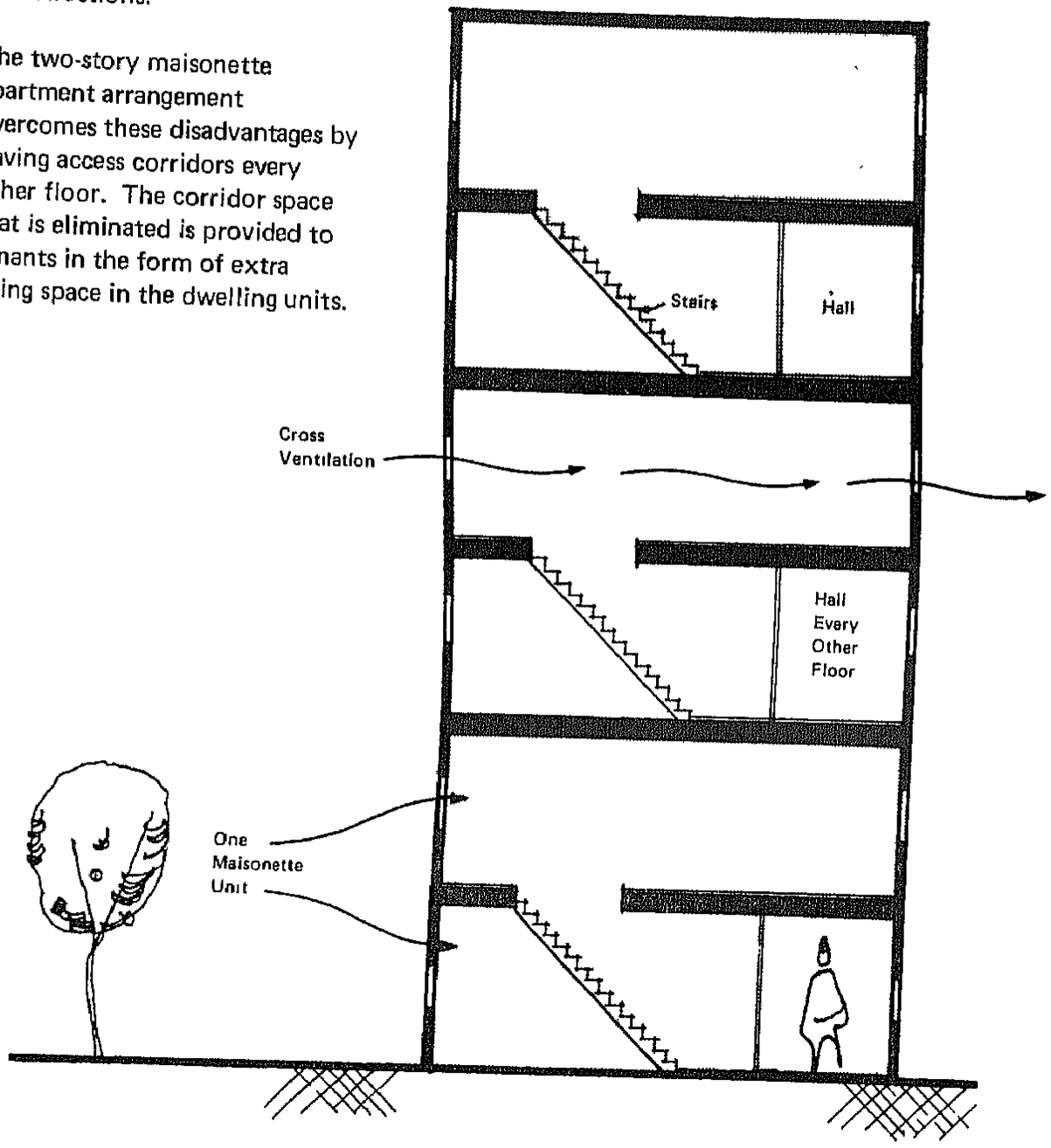


FIGURE 1.6
TWO-STORY MAISONETTES IN HIGH-RISE CONSTRUCTION

1.7 EXPANDABLE PANELIZED HOUSE DESIGN

Housing Manufacturer:
Republic Steel

Most modular housing systems utilize modules placed side by side and/or one upon the other. This one-story, single-family, detached system provides five basic modules, site erected from panels, which can be flexibly arranged to allow a variety of shapes or easy additions to the basic house. The five basic components of the system are:
(1) entry connector element;
(2) living room—kitchen—dining—utility room module;
(3) two-bedroom—bath module;
(4) family room—bedroom—bath module; and
(5) three-bedroom—bath module.

The entry connector element separates the modules allowing each to serve its own function.

The basic house can be either "H", "I", or "L" shaped or variations thereof depending on the required space and orientation and can be expanded by adding additional modules. Figures 1.7a and b illustrate two alternative arrangements.

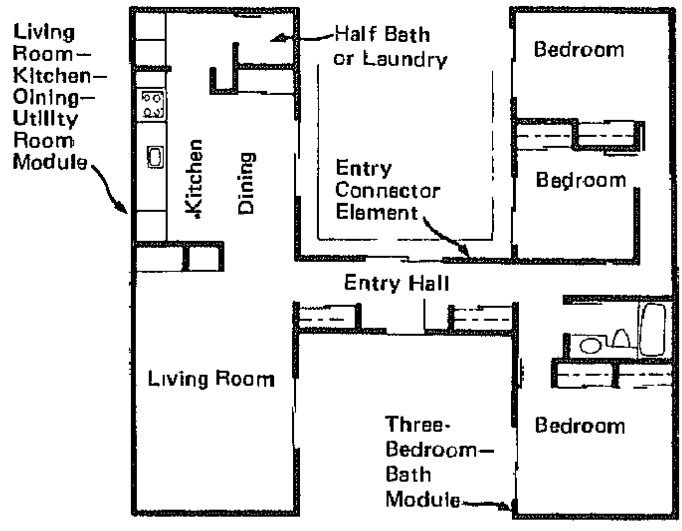


FIGURE 1.7a
MODULES ARRANGED PARALLEL TO EACH OTHER

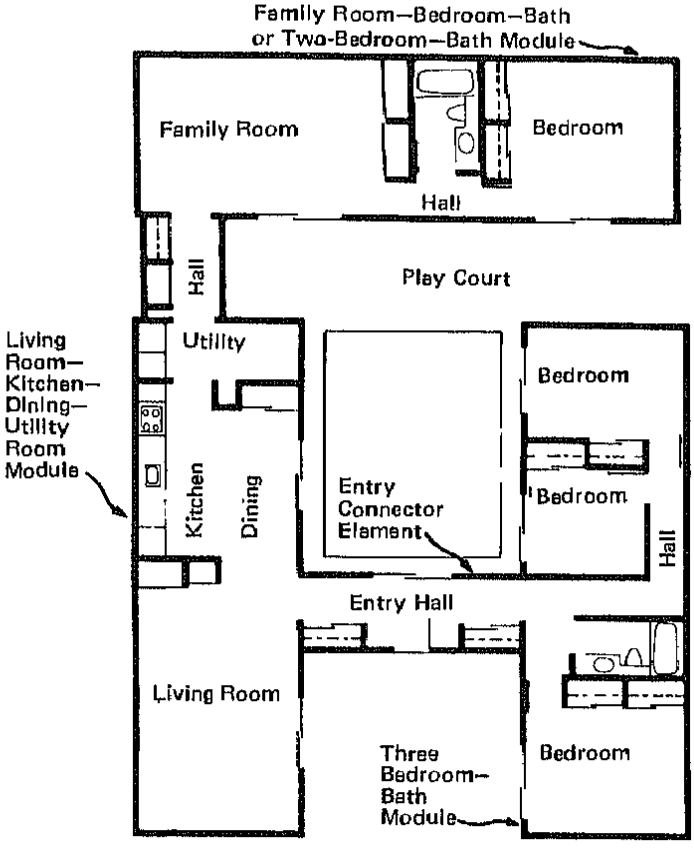


FIGURE 1.7b
MODULES ARRANGED AROUND A COURTYARD

1.8 MEGASTRUCTURE CREATES LAND IN THE AIR

Housing Manufacturer:
Townland

The Townland concept is to create new "land" while at the same time providing housing units. Two distinct subsystems are used. The supported land system (SLS) consists of a structural framework of vertical columns and decks that supports houses above ground level, carries all normal utilities and provides pedestrian walkways and back yard areas where grass, trees and shrubs can be planted. Infill units, which can be either modular or panular, are placed two tiers high at ground level and three tiers high on each upper level. Since the infill units are separate from the SLS, architectural variety is possible. The SLS features a unique utilities subsystem within the frame deck (see 2.5).

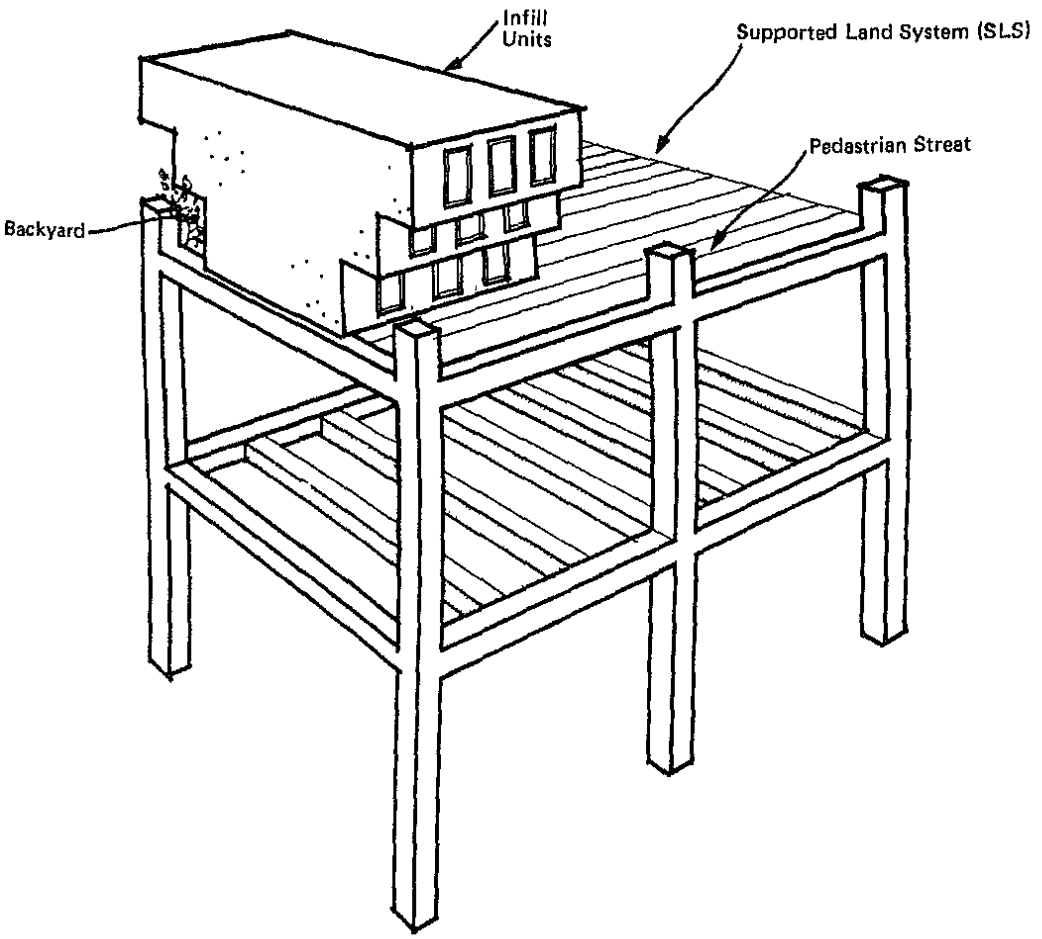


FIGURE 1.8
MEGASTRUCTURE AND TYPICAL INFILL UNIT

2.
STRUCTURE

2.1 PLUG-ON BALCONY UNIT

Housing Manufacturer: CAMCI

One of the time-saving, novel components of this concrete panel system is the quickly attached, precast concrete balcony module—Figure 2.1a.

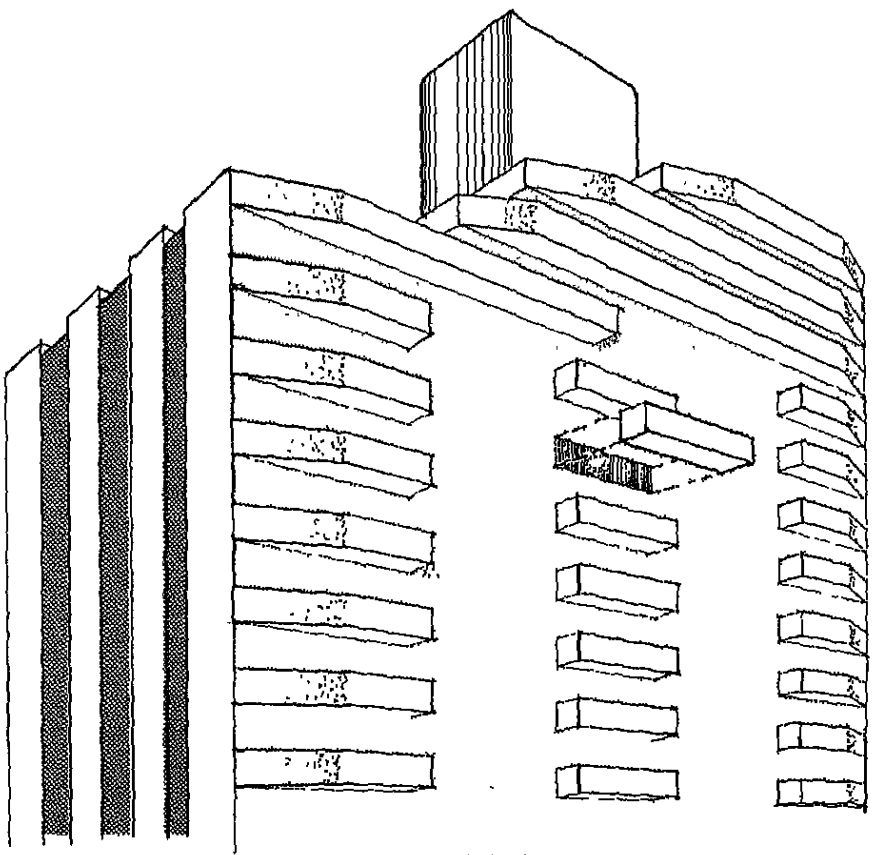


FIGURE 2.1a
TYPICAL BALCONY ARRANGEMENT

2.1 PLUG-ON BALCONY UNIT
continued

The module is bolted and grouted to the exterior concrete walls of the building through threaded inserts cast into the side walls—Figure 2.1b. The shape of the balcony module can be varied giving the architect the opportunity to design a range of economical and pleasant building facades.

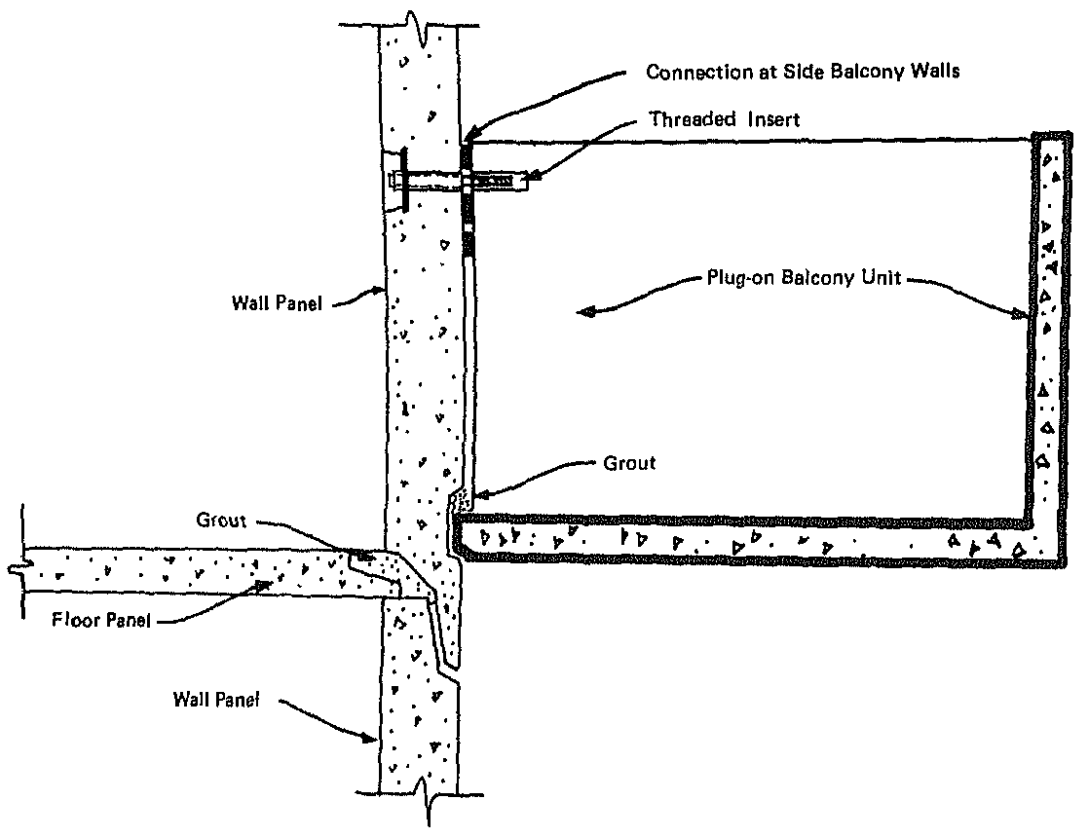


FIGURE 2.1b
SECTION OF PLUG-ON BALCONY UNIT

2.2 WOOD MODULE PUSH-OUT AND FOLD-OUT ELEMENTS

Housing Manufacturer: Levitt

One of the architectural design problems with volumetric modules is to break up their boxy appearance. Highway transportation of modules limits roof overhangs and side wall protrusions such as balconies and bay windows. Where these features have been employed on modules they are usually site-attached add-ons that may suffer in appearance from site workmanship. Further, on-site labor and additional transportation costs for these separate items limit their use.

These problems have been solved in the Levitt system by developing several unique construction details. Hinged roof members are laid flat on the module during transportation and folded into place when the modules are erected—Figures 2.2a, b, c and d. Push-out bay window units and closets are stored within the module during transit and set up at the site—Figure 2.2d.

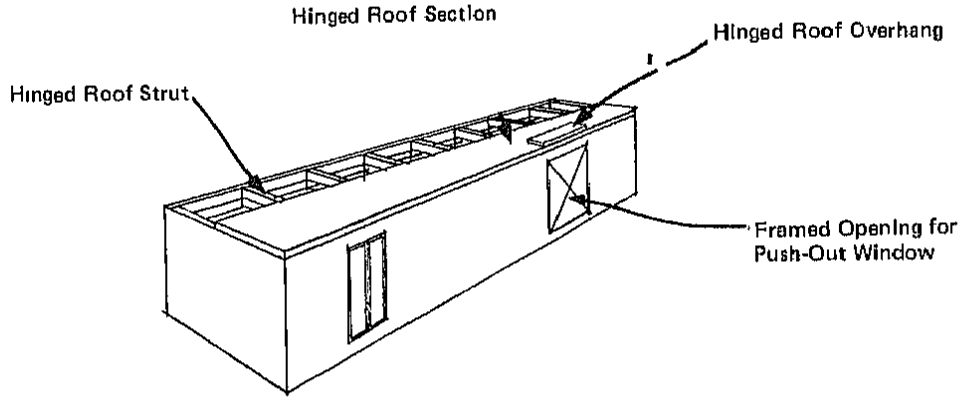


FIGURE 2.2a
SHIPPING CONFIGURATION OF MODULE

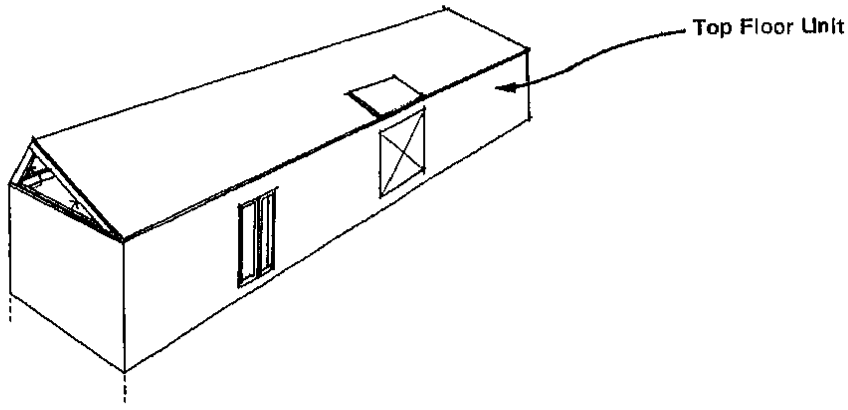


FIGURE 2.2b
ROOF SECTION, ROOF STRUT AND OVERHANG FOLDED INTO PLACE

2.2 WOOD MODULE PUSH-OUT AND FOLD-OUT ELEMENTS
continued

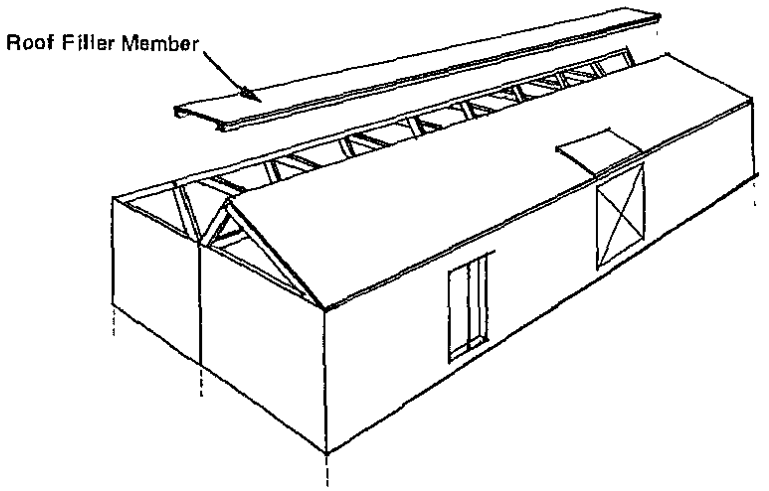


FIGURE 2.2c
ROOF FILLER MEMBER PLACED BETWEEN MODULES

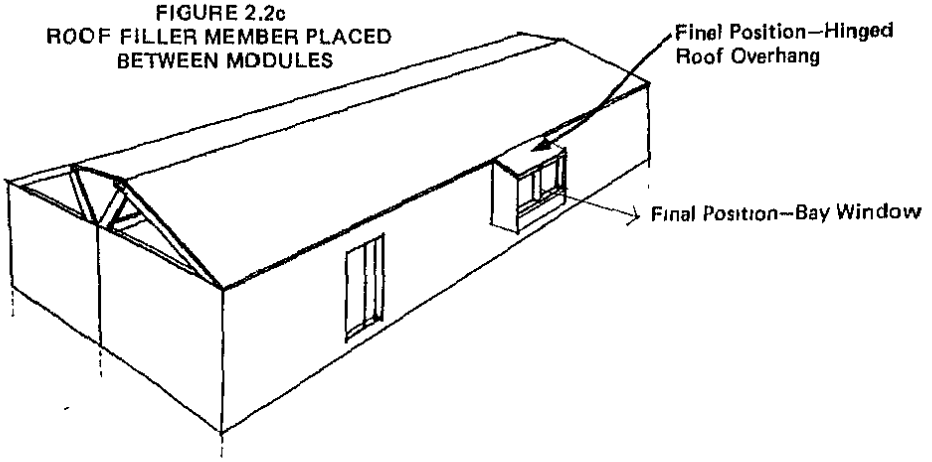


FIGURE 2.2d
BAY WINDOW PUSHED OUT FROM STORAGE LOCATION IN MODULE

2.3 TRANSVERSE PARTY WALLS IN MODULAR DWELLINGS

Housing Manufacturers:

Levitt	Scholz
National Homes	Townland

When volumetric modules are used to construct multi-family housing units, the party wall between dwellings usually occurs as the common interface between adjacent modules-Figure 2.3a. Several housing manufacturers utilize modules placed lengthwise in the structure with party walls occurring within the modules—Figure 2.3b. This allows floor plan flexibility since the typical 12 foot maximum module width dictated by transportation considerations is no longer a constraint on room size. See 4.3 for an acoustical problem resulting from this arrangement and a possible solution.

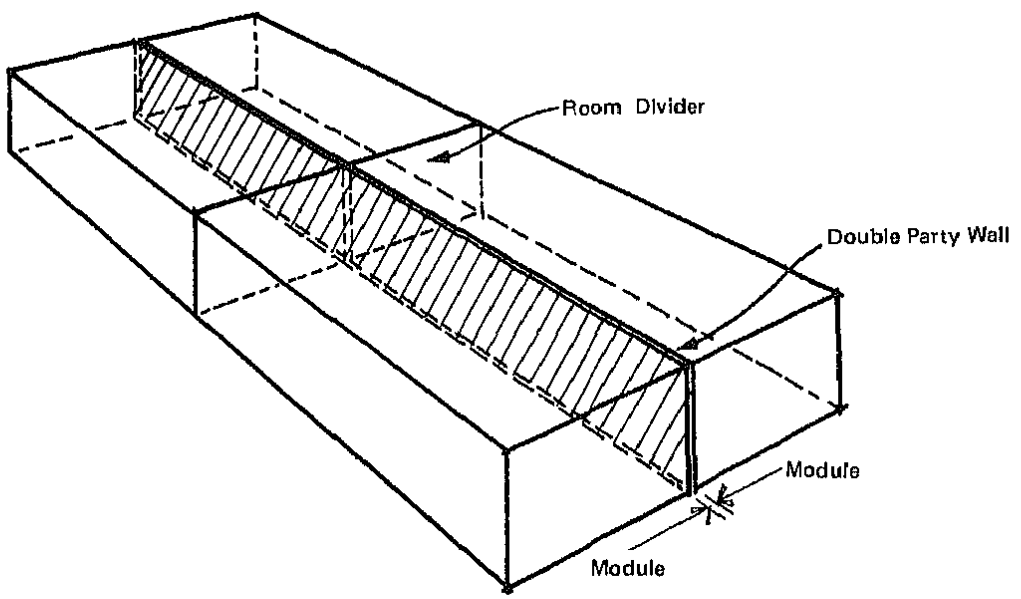


FIGURE 2.3a
PARTY WALL AT MODULE TO MODULE INTERFACE

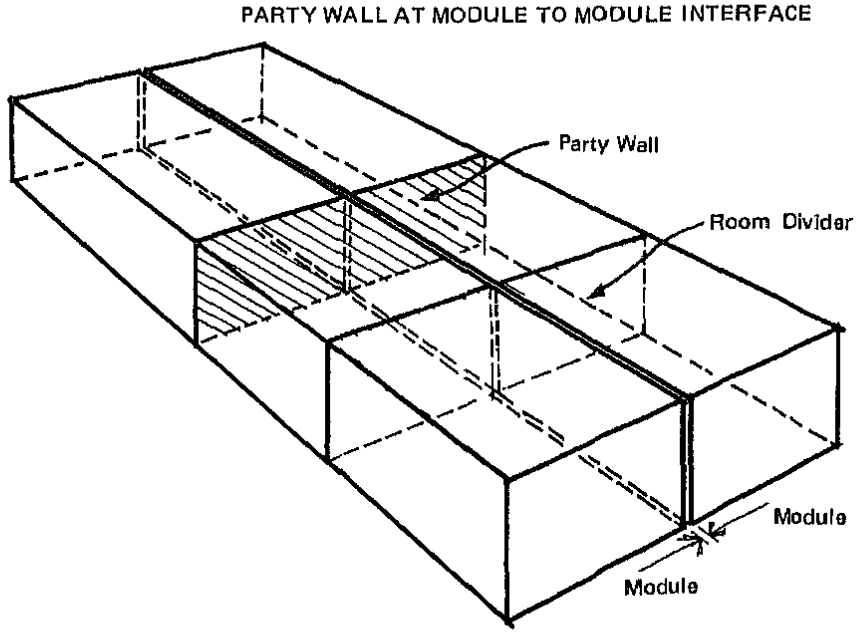


FIGURE 2.3b
PARTY WALL WITHIN MODULES

2.4 SLIT METAL STUDS REDUCE THERMAL BRIDGING

Housing Manufacturer:
National Homes

Metal framing has been designed to provide the required structural performance when used in load-bearing walls. A possible problem with metal framing is "ghosting", the outlining of the framing, caused by high heat flow through the material.

A countermeasure to high thermal conductivity in metal members is to slit the studs in exterior walls to provide greater thermal resistance while maintaining structural strength.

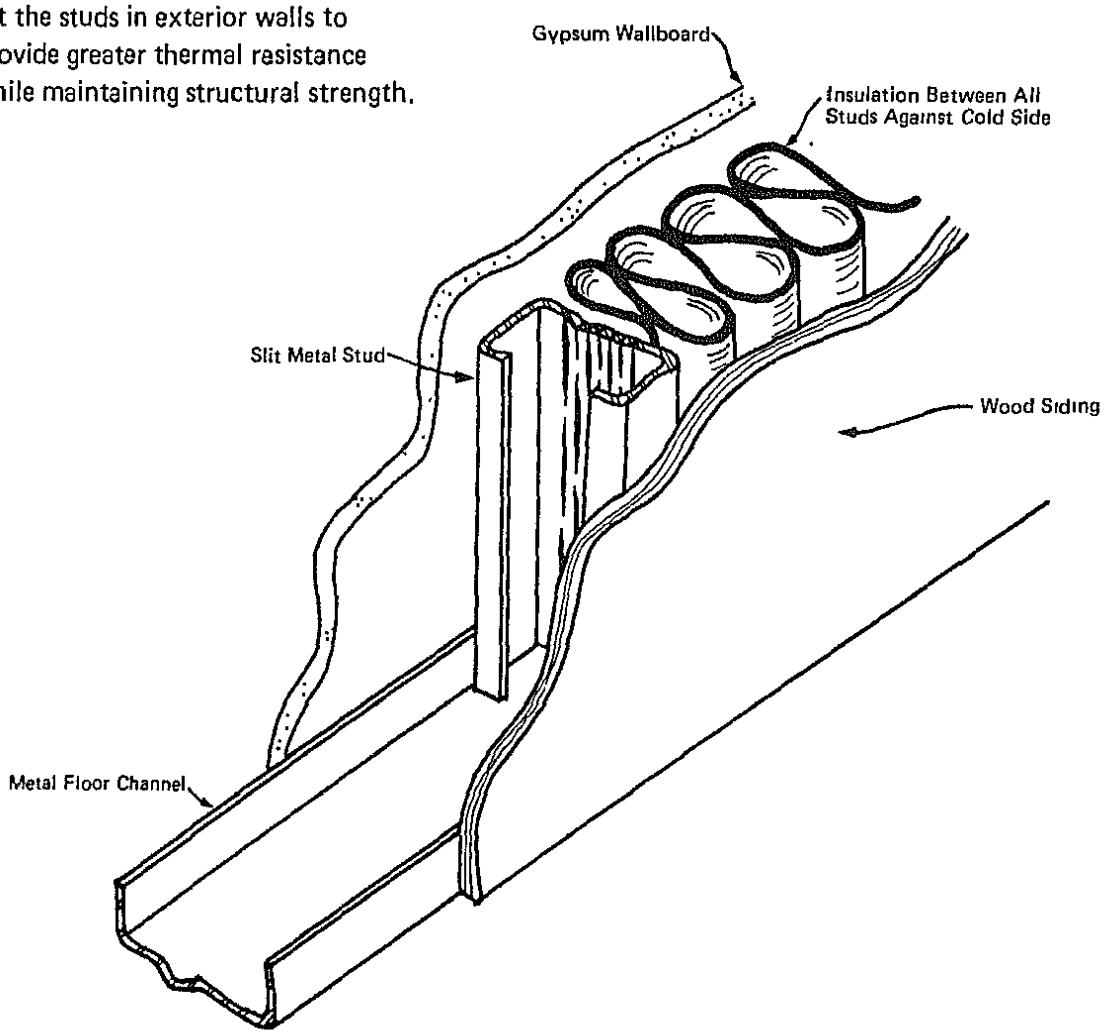


FIGURE 2.4
EXTERIOR LOAD-BEARING WALL CONSTRUCTION

2.5 MEGASTRUCTURE UTILITY SYSTEMS LOCATED IN UNDERGROUND CHASE

Housing Manufacturer: Townland

The Townland megastructure has a utility distribution system that is carried in an understreet chase. This system consists of five distinct elements:

1. A chase located under the street.
2. A vertical riser at the entry of each unit from the chase.
3. An in-channel lateral chase to the dwelling.
4. Channel crossover connections.
5. Vertical riser manifolds from floor to floor of the megastructure land system.

Typical services contained in the utility chase are:

- Electrical Distribution
- Telephone Cable
- TV Cable
- Domestic Cold Water
- Gas and/or Oil Piping
- Storm Drain Piping
- Sanitary Drain Piping
- Vent Stacks
- Spare Conduit (for future services)

See 1.8 for a more detailed description of the megastructure.

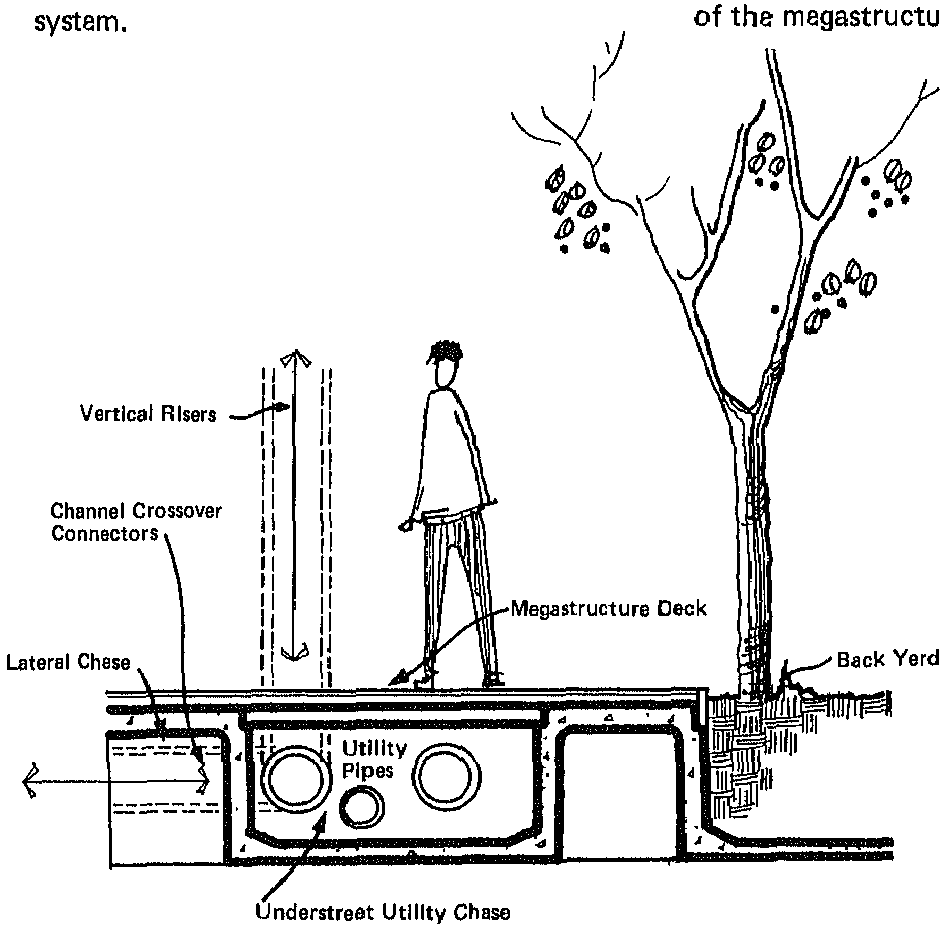


FIGURE 2.5
MEGASTRUCTURE UNDERGROUND CHASE

2.6 MULTI-PURPOSE GRADE BEAM

Housing Manufacturer:
Republic Steel

The general structural design of the Republic Steel system consists of components field-assembled into modules—Figure 2.6a. Sandwich panels (see 3.13) are used for roof, floor and wall members and formed steel joists and grade beams for the floor framing.

In addition to serving as a structural support for the floor and wall panels, the grade beam serves as a duct for the HVAC distribution system—Figure 2.6b. See 5.3 for a description of the exterior mounted heating and air conditioning unit. Thermal insulation inside the grade beam reduces heat loss and absorbs airborne noise. The beam also contains separate raceways for high voltage and low voltage electrical distribution. See 7.3 for a description of the surface-mounted wiring technique used for electrical distribution from the grade beam to the house outlets.

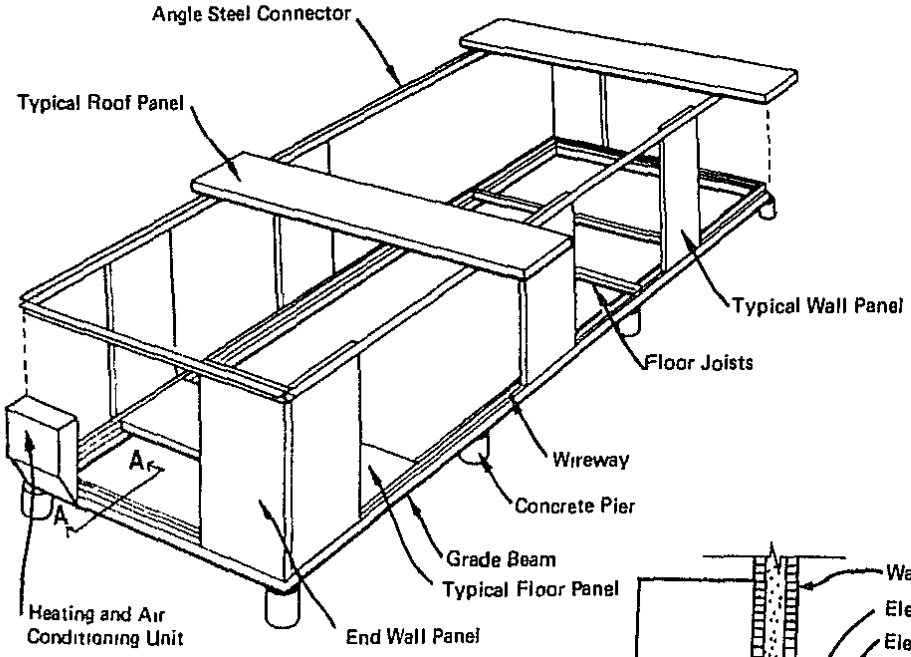


FIGURE 2.6a
SCHEMATIC OF HOUSING SYSTEM

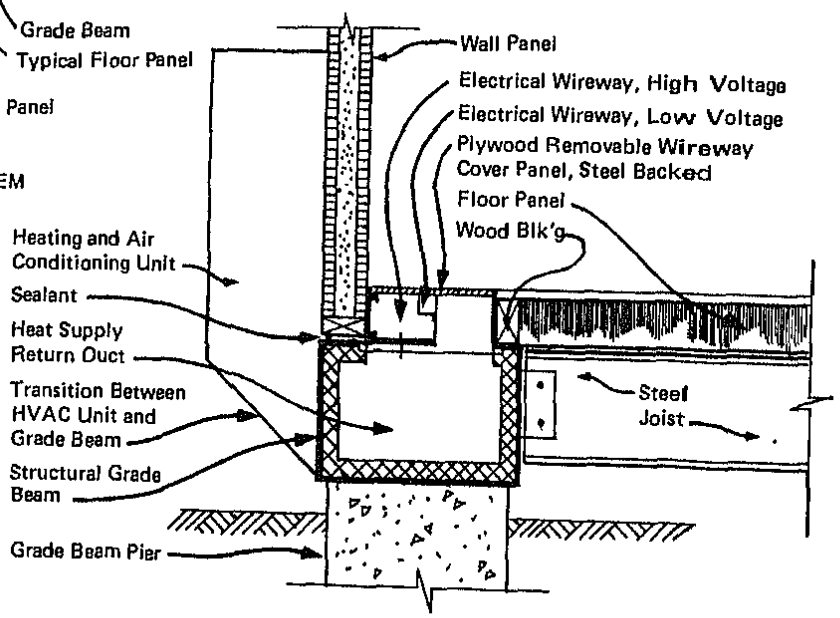


FIGURE 2.6b
SECTION A-A THROUGH GRADE BEAM

2.7 NON-STANDARD SIZE PLYWOOD USED IN FLOOR

Housing Manufacturer: Levitt

In conventional construction, 4 x 8 foot sheets of plywood subflooring are laid perpendicular to the floor joists—Figures 2.7a and 2.12h. This housing system used special 4 foot x 11 foot 4-1/2 inch sheets placed parallel to the joists full width of the module—Figure 2.7b. This allows production line economy and eliminates the need of edge blocking since all edges are supported by joists.

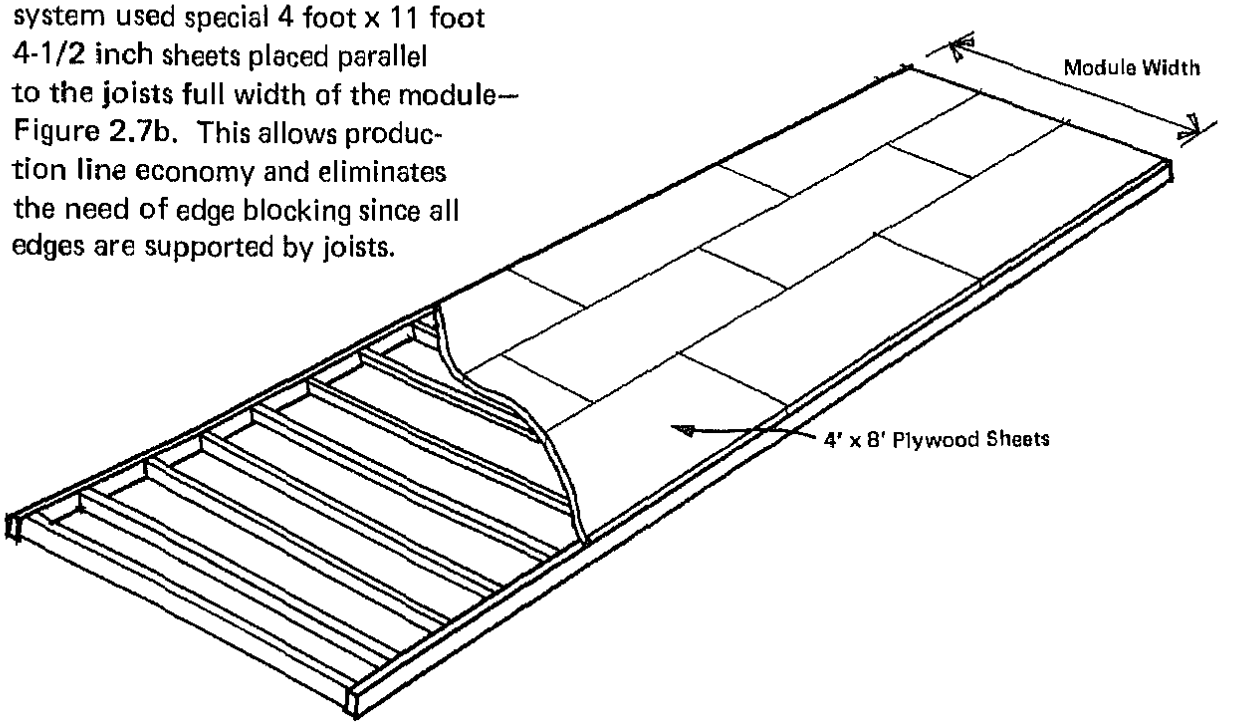


FIGURE 2.7a
CONVENTIONAL PLYWOOD SUBFLOOR LAYOUT

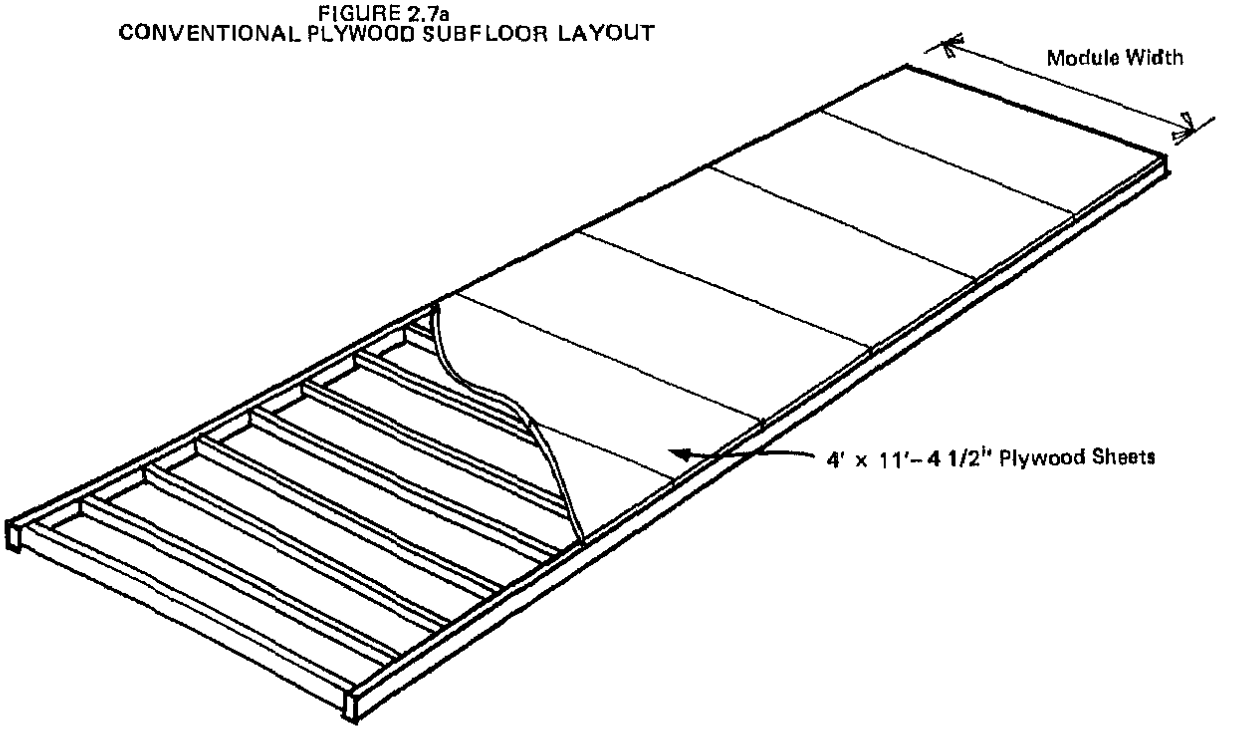


FIGURE 2.7b
LEVITT PLYWOOD SUBFLOOR LAYOUT

2.8 ADHESIVE BONDING OF FLOORS FOR INCREASED STRENGTH AND RIGIDITY

Housing Manufacturers:
Home Building Corp.
General Electric

Wood floor systems conventionally constructed of 2x8 joists with plywood subfloor attached by nailing, may squeak with age or have a "springy" nature. Home Building Corp. uses a one-sided, stress-skin panel consisting of tongue and groove plywood glued and nailed to 2x6 joists on 16 inch centers. In addition to providing a savings in materials, the likelihood of squeaking is reduced and stiffness is increased by the interaction of the plywood and joists.

The General Electric housing system uses a floor system of 2x8 joists on 24 inch centers connected with glue and nailing.

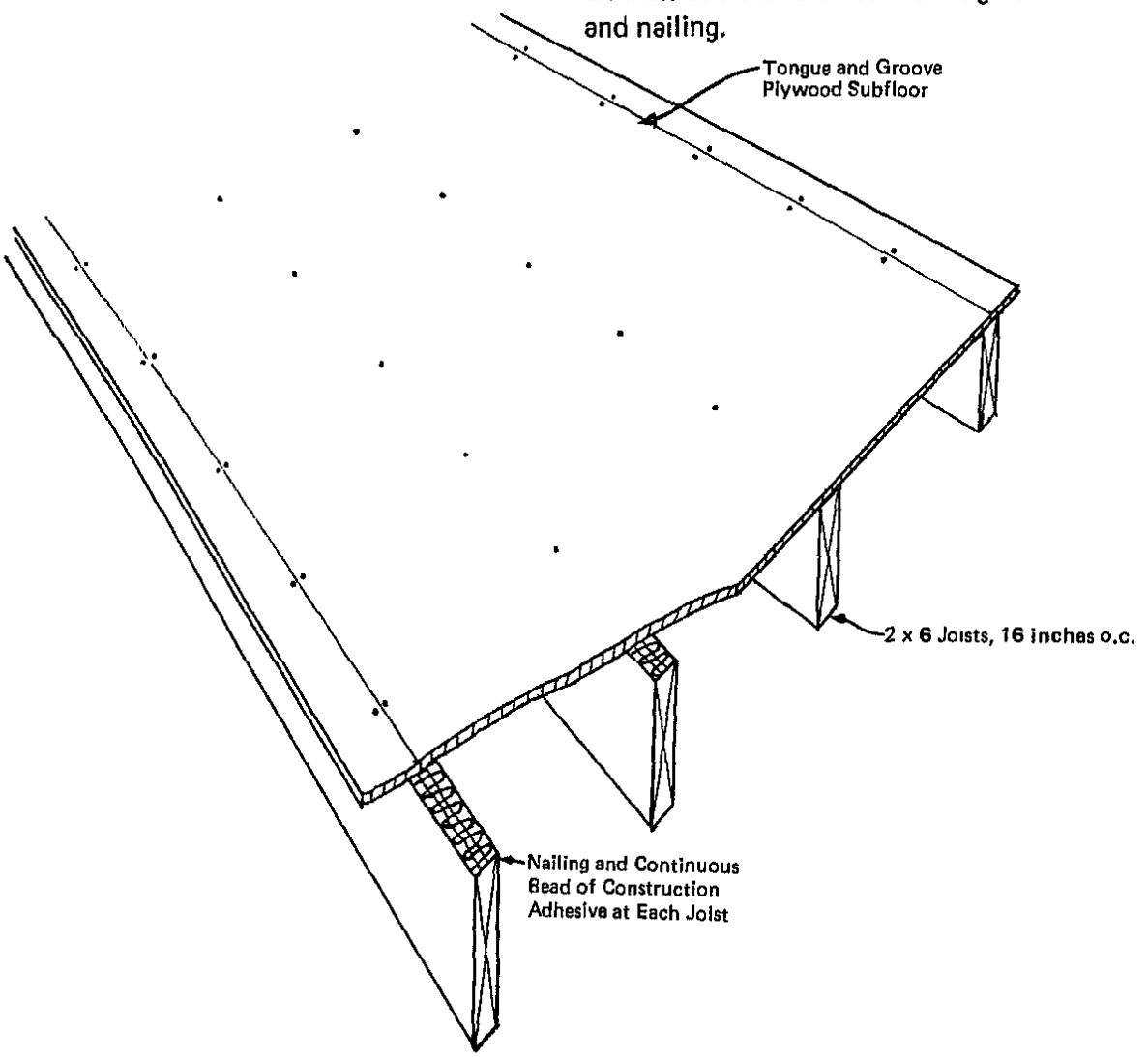


FIGURE 2.8
STRESS–SKIN FLOOR CONSTRUCTION

2.9 ATTACHING SHEATHING WITH POLYMER BONDING ADHESIVE

Housing Manufacturer:
Pemtom

Recent advances in construction adhesive technology have broadened the use of adhesives in structural applications. The time constraint of industrialized housing has led to the use of an adhesive that has the structural strength of a resorcinol (a time-proven wood adhesive) and the set-up speed of a contact adhesive. This product, used by Pemtom, provides stiffness for the structural elements by creating wood frame/plywood stress skin exterior wall panels. The rapid cure of the adhesive means that only minimal nailing is needed to initially hold the components together while the adhesive sets.

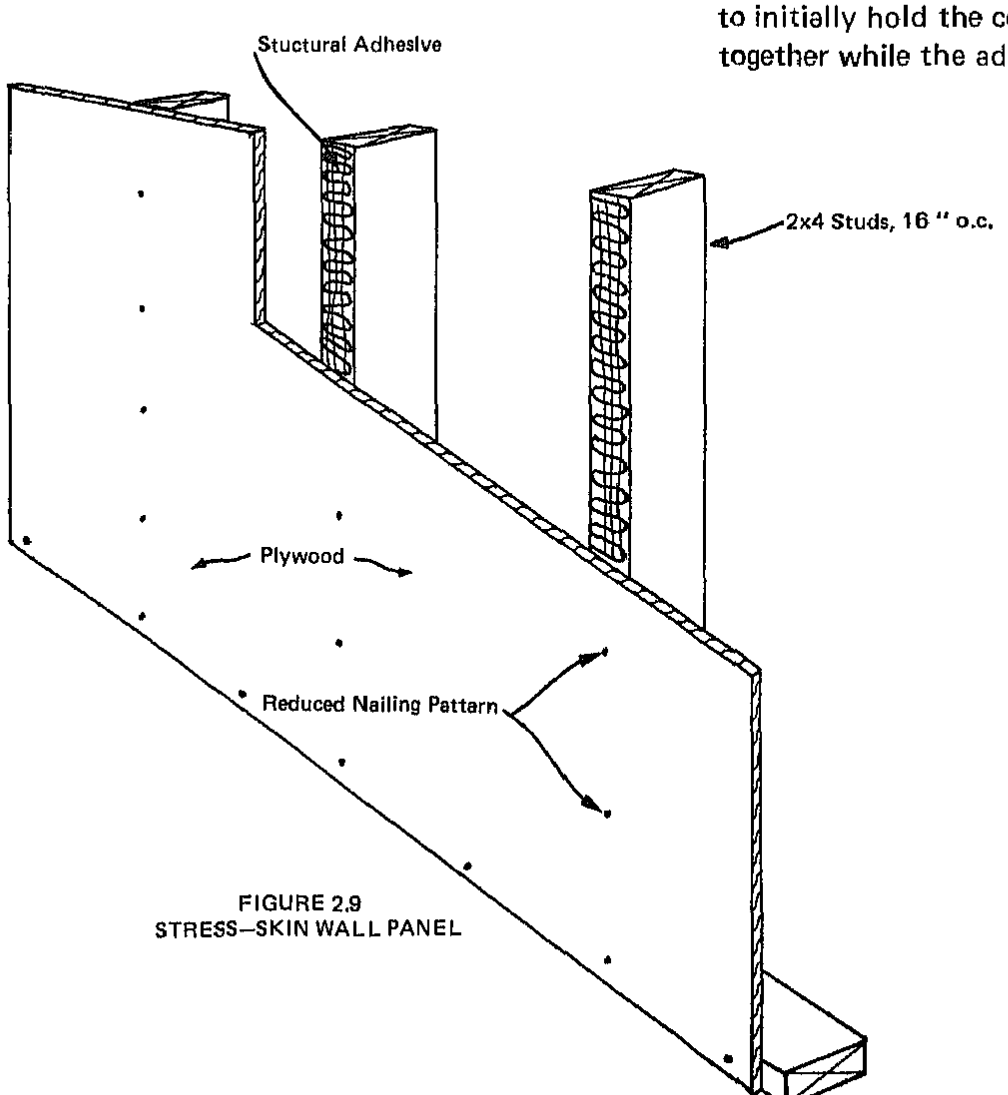


FIGURE 2.9
STRESS–SKIN WALL PANEL

2.10 PANEL JOINT DETAILS

Housing Manufacturers:

- Republic Steel
- TRW
- Pantek
- Material Systems

Closed panel systems present field fastening problems not normally encountered in conventional housing construction. Because of some innovative materials used in panel construction, nailing cannot be used so extensively, requiring that other interlocking details, adhesives or special fasteners take their place.

Republic Steel

Paper honeycomb steel faced sandwich panels are used for roof, floor and wall members. See 1.7, 2.6 and 3.13 for descriptions of various system components. A combination of screws and tongue and groove joints are used to connect structural members.

Attachment between the roof panels and exterior wall panels is made with steel clip angles and lag screws, Figures 2.6a and 2.10a.

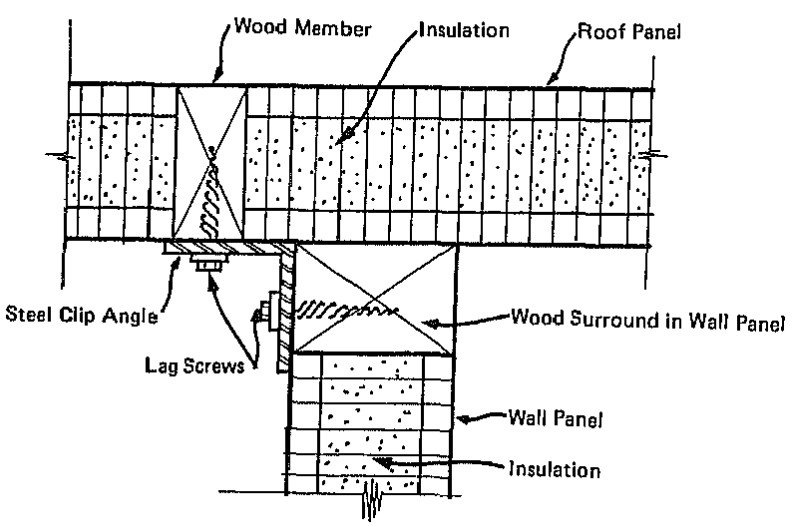


FIGURE 2.10a
REPUBLIC STEEL–WALL/ROOF CONNECTION

2.10 PANEL JOINT DETAILS
continued

Vertical connections between wall panels and horizontal connections between roof panels are made by mating of tongue and groove wood edge members, Figures 2.10b and c. The roof panel splice is sealed from the weather with a light gage steel roof cap which extends down over the vertical extension of the top sheet. The wall panel joint is sealed with butyl sealant in the recessed channel on the exterior surface. All interior joints receive vinyl tape in the accentuated interior joint for sealing and decorative purposes, except when used as a raceway for electric wiring (see 7.3).

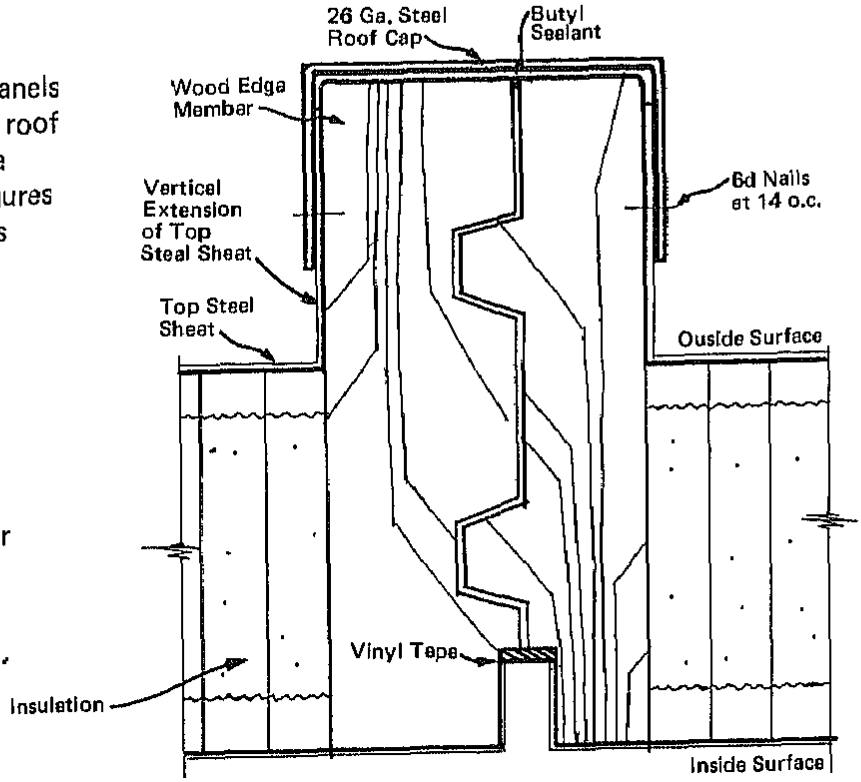


FIGURE 2.10b
REPUBLIC STEEL– ROOF PANEL JOINT

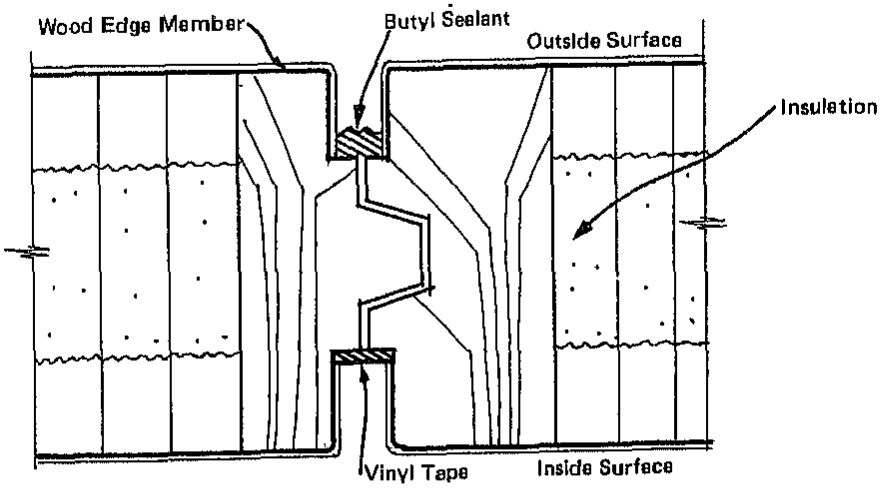


FIGURE 2.10 c
REPUBLIC STEEL– VERTICAL WALL JOINT

2.10 PANEL JOINT DETAILS
continued

TRW

Paper honeycomb core gypsum faced sandwich panels are used for wall, floor and roof/ceiling members, Figure 2.10d. End walls closing the module are conventional wood stud construction. See 3.11 for description of the TRW sandwich panel construction.

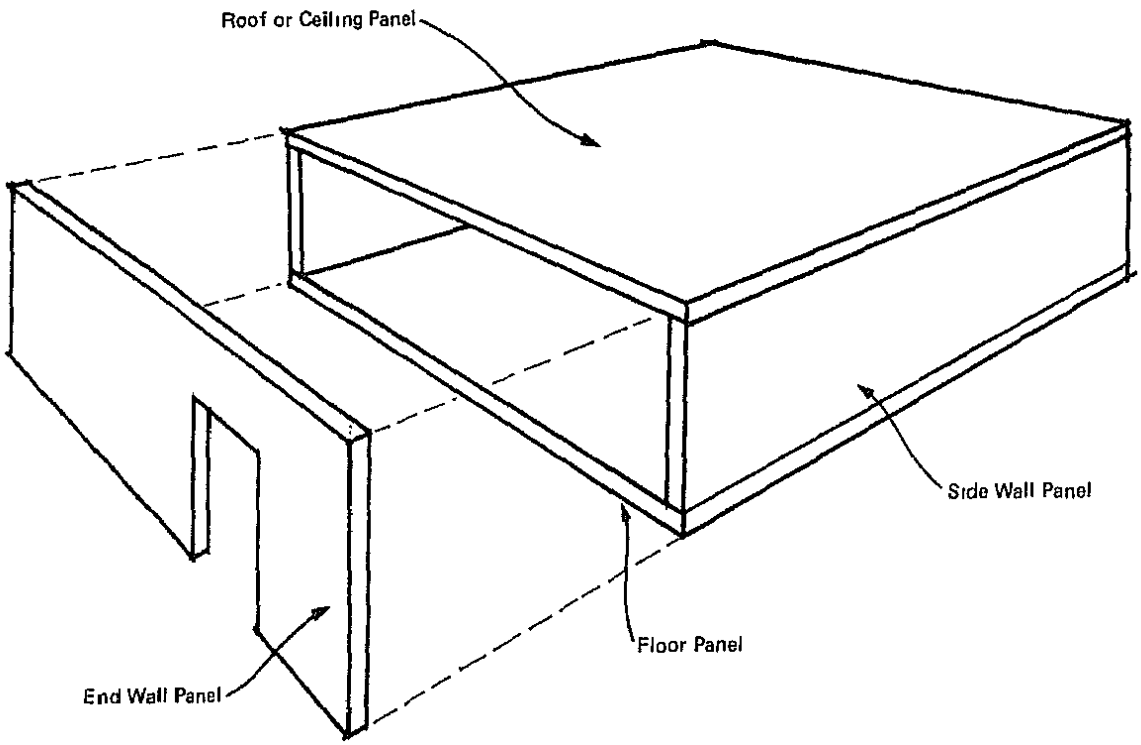


FIGURE 2.10 d
TRW– FIBER-SHELL MODULE CONSTRUCTION

A combination of lag bolts, wood dowels, and adhesives is used for panel to panel connection. The side wall panel to floor panel joint is illustrated in Figure 2.10e. Wood positioning dowels are placed in the floor panel wood closeout, a continuous bead of adhesive is applied to the plywood surface and the side wall panel is lowered onto the dowels to complete the joint. Joining of the side wall panel to the roof/ceiling panel is done in a similar manner.

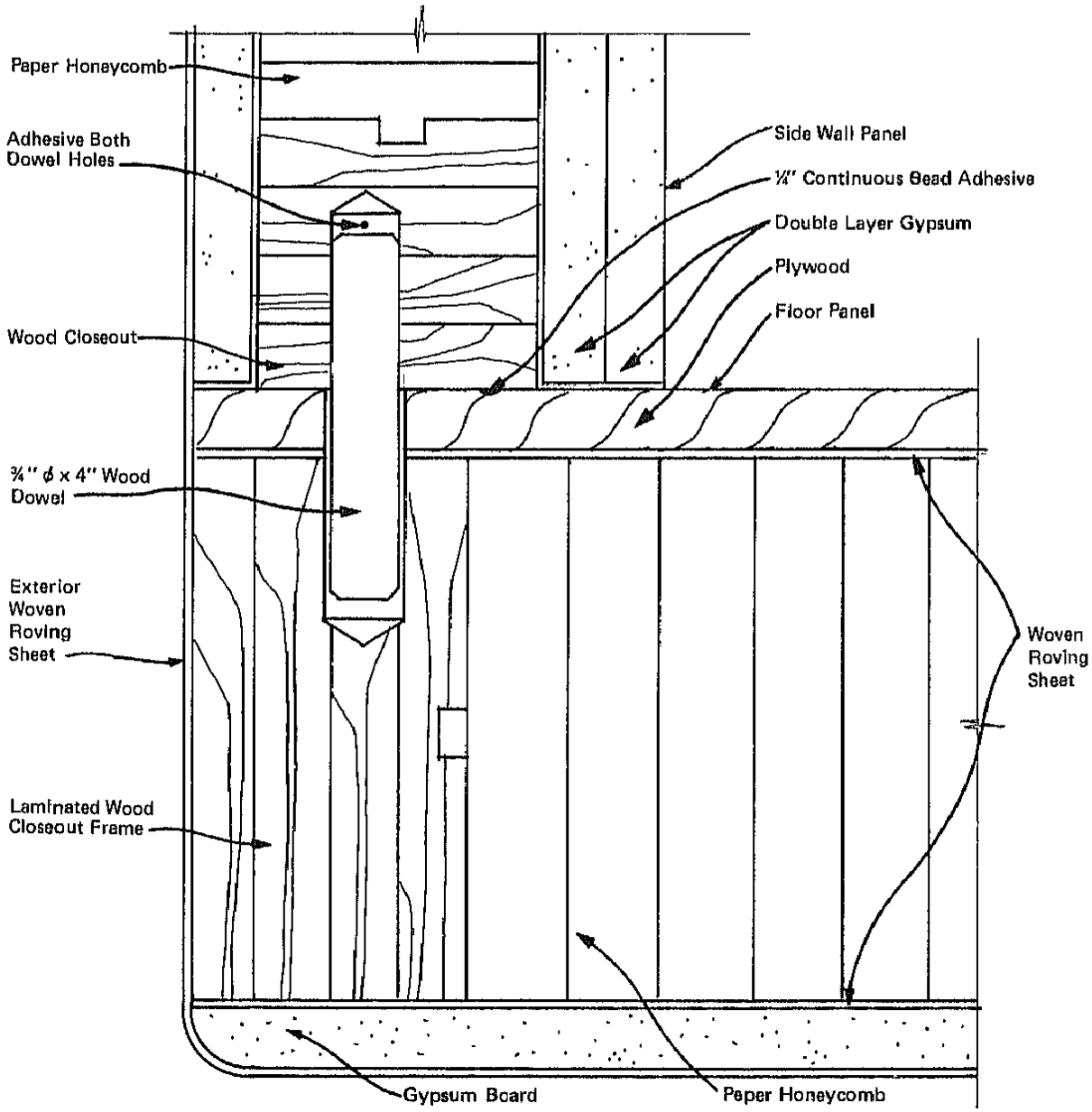


FIGURE 2.10e
TRW– TYPICAL SIDE WALL PANEL TO FLOOR DETAIL

2.10 PANEL JOINT DETAILS
continued

The end wall panel attachment to the floor panel uses adhesives and lag bolts, Figure 2.10f.

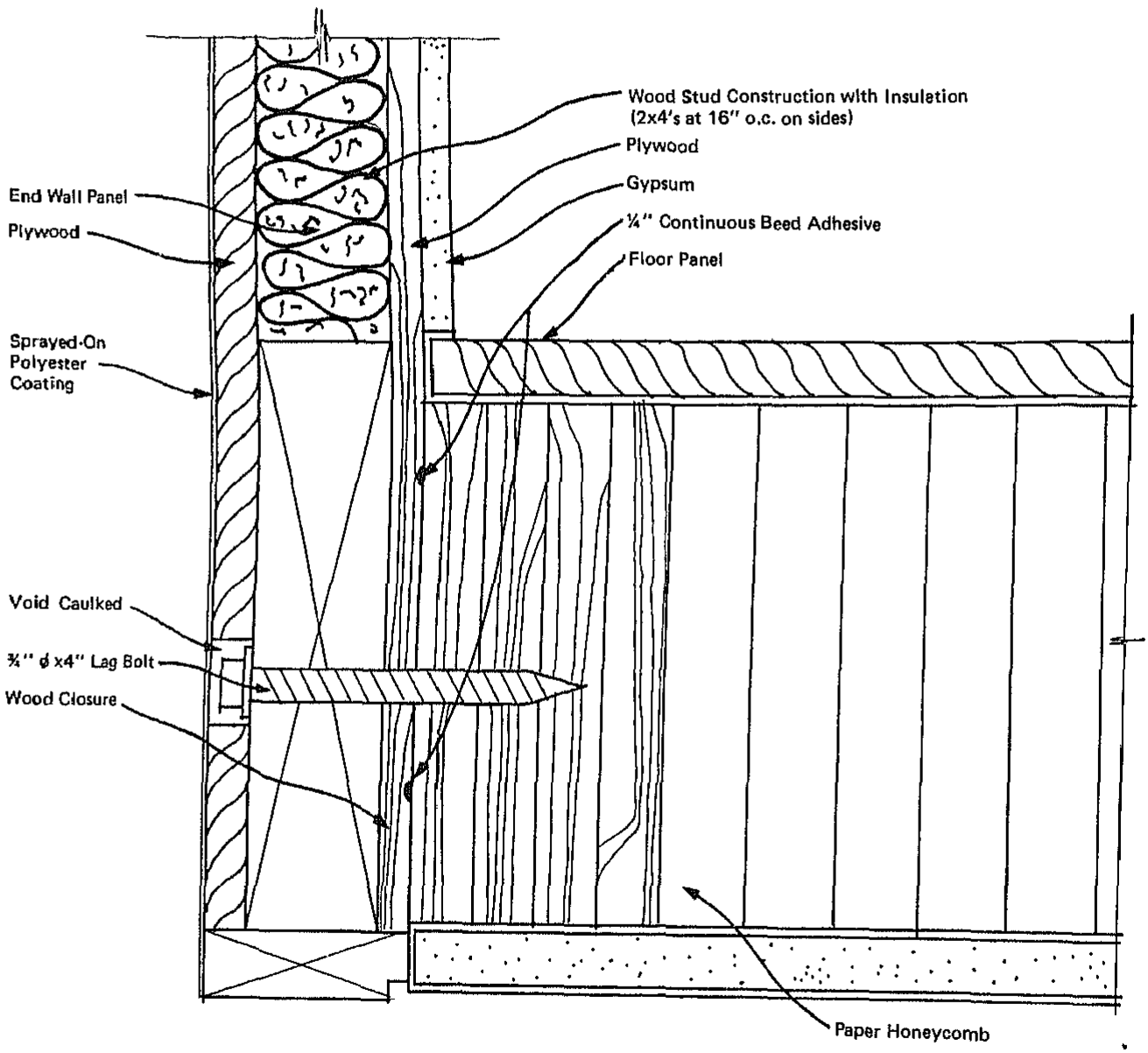


FIGURE 2.10f
TRW– TYPICAL END WALL PANEL TO FLOOR DETAIL

2.10 PANEL JOINT DETAILS
continued

Pantek

Factory manufactured polyurethane foam sandwich panels are used in this housing system. See 3.14 for a description of the sandwich panel construction.

Aluminum extrusions frame all four edges of the wall panels. The vertical wall to wall connection is made by interlocking adjacent edge extrusions with a "H" shaped spline, Figure 2.10g. Synthetic rubber wedges are then positioned into each joint to tighten the connection and provide a water barrier.

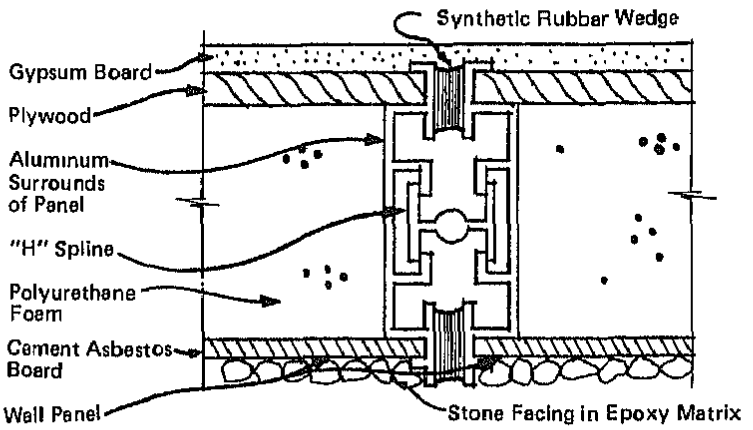


FIGURE 2.10 g
PANTEK– VERTICAL WALL PANEL JOINT

Similiarly, walls are connected with a "H" spline to an aluminum base extrusion anchored to the concrete floor slab, Figure 2.10h.

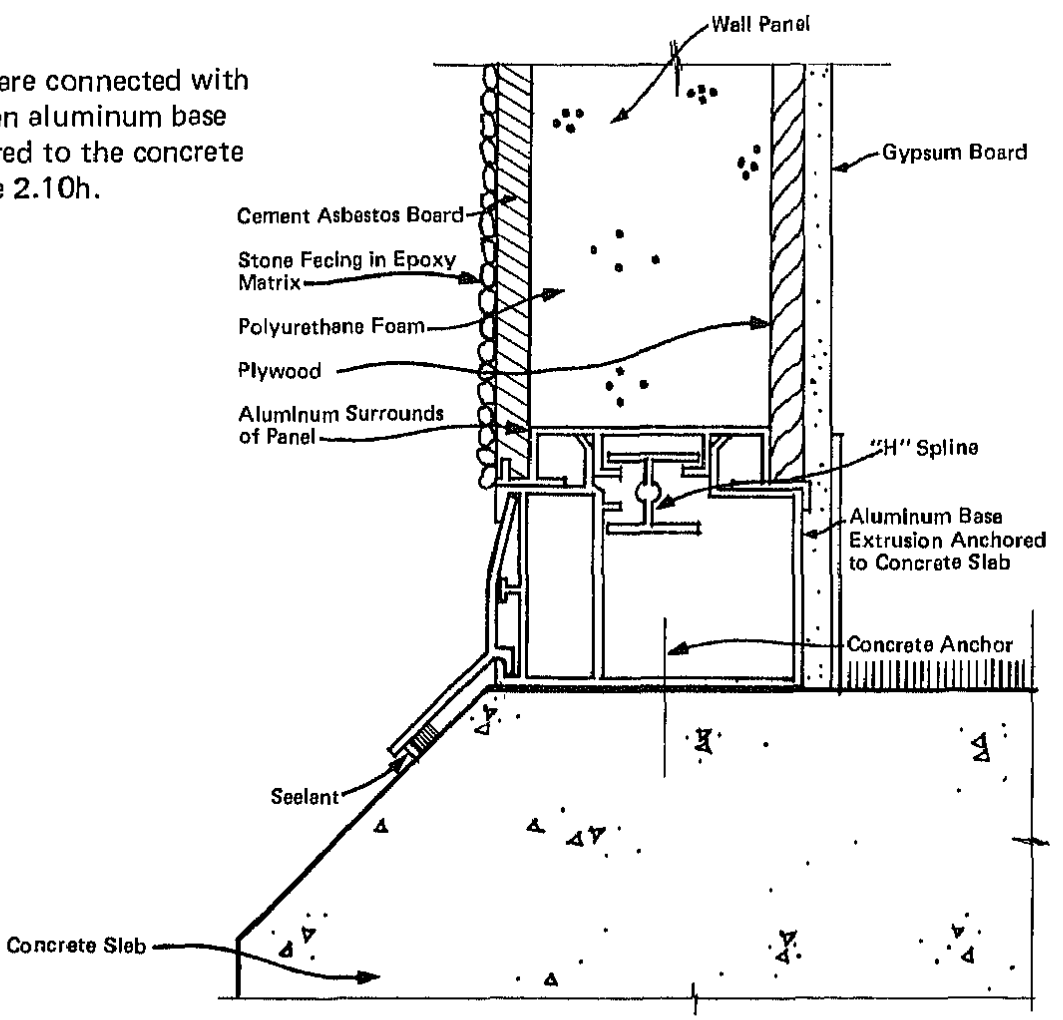


FIGURE 2.10h
PANTEK–EXTERIOR WALL PANEL TO SLAB JOINT

Material Systems Corporation

Roof and wall sandwich panels are constructed from laminated sheets of polyester resin reinforced with chopped strands of glass fibers. See 3.12 for description of panels. A combination of adhesives and field nailing through perimeter wood framing is used to connect structural components.

The corner wall panel joint is made with end closure pieces of laminated material attached with adhesive to the wall panels, Figure 2.10i. Mineral wood insulation is placed in all voids.

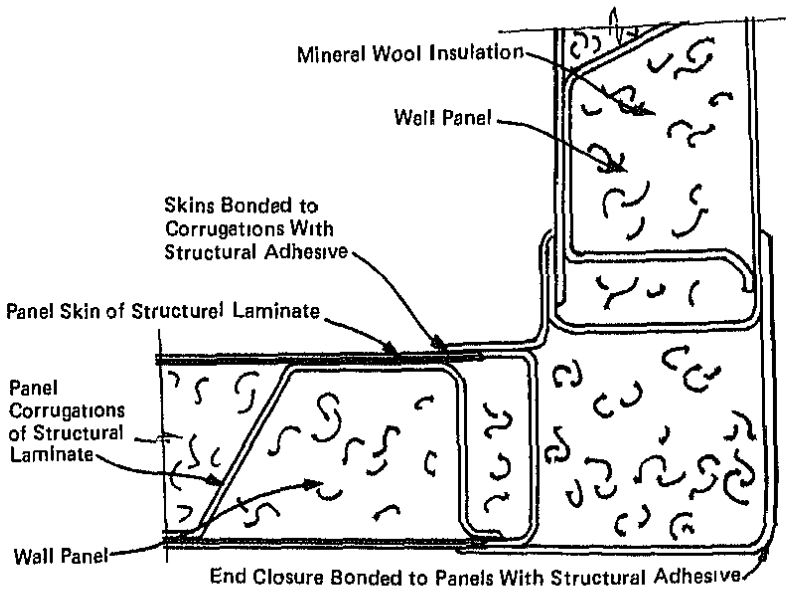


FIGURE 2.10i
MATERIAL SYSTEMS–CORNER WALL PANEL JOINT

The connection between the wall panel and roof/ceiling depends on a combination of adhesives and nailing, Figure 2.10j. The 2 x 6 rim joist of the roof panel is glued to the 2 x 4 header of the wall panel. In addition, a fascia support is nailed to both members.

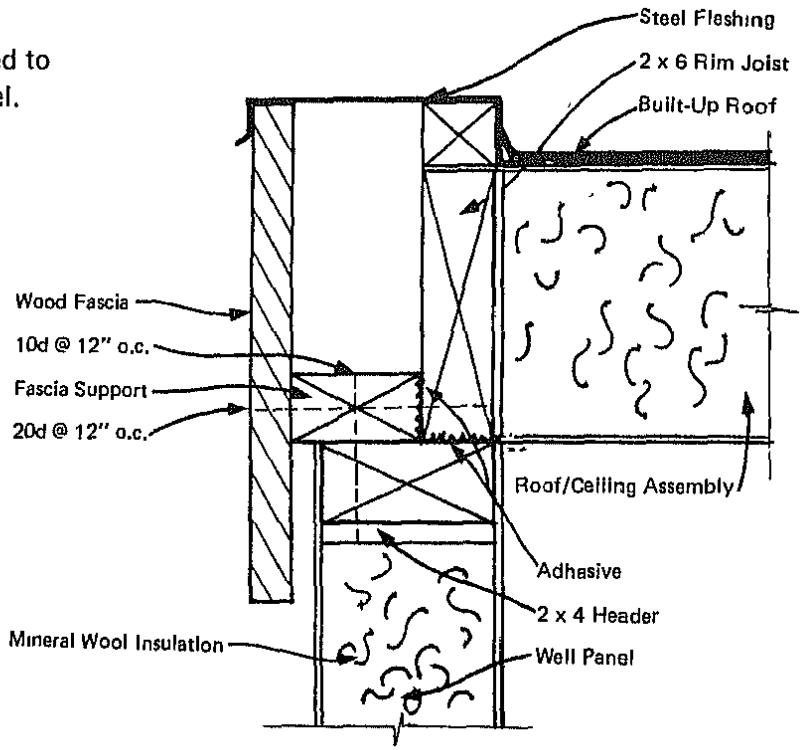


FIGURE 2.10j
MATERIAL SYSTEMS–EXTERIOR WALL-ROOF JOINT

2.11 ATTACHING SILL TO STEEL BEAM WITH STEEL BANDS

Housing Manufacturer: Home Building Corp.

Wood sill plates are normally attached to steel support beams with such conventional fasteners as bolts which can require the time-consuming task of drilling holes in the beam flange. The method of attachment used in this housing system is by regularly spaced galvanized steel bands which can be quickly placed around the assembly with a banding tool in the field.

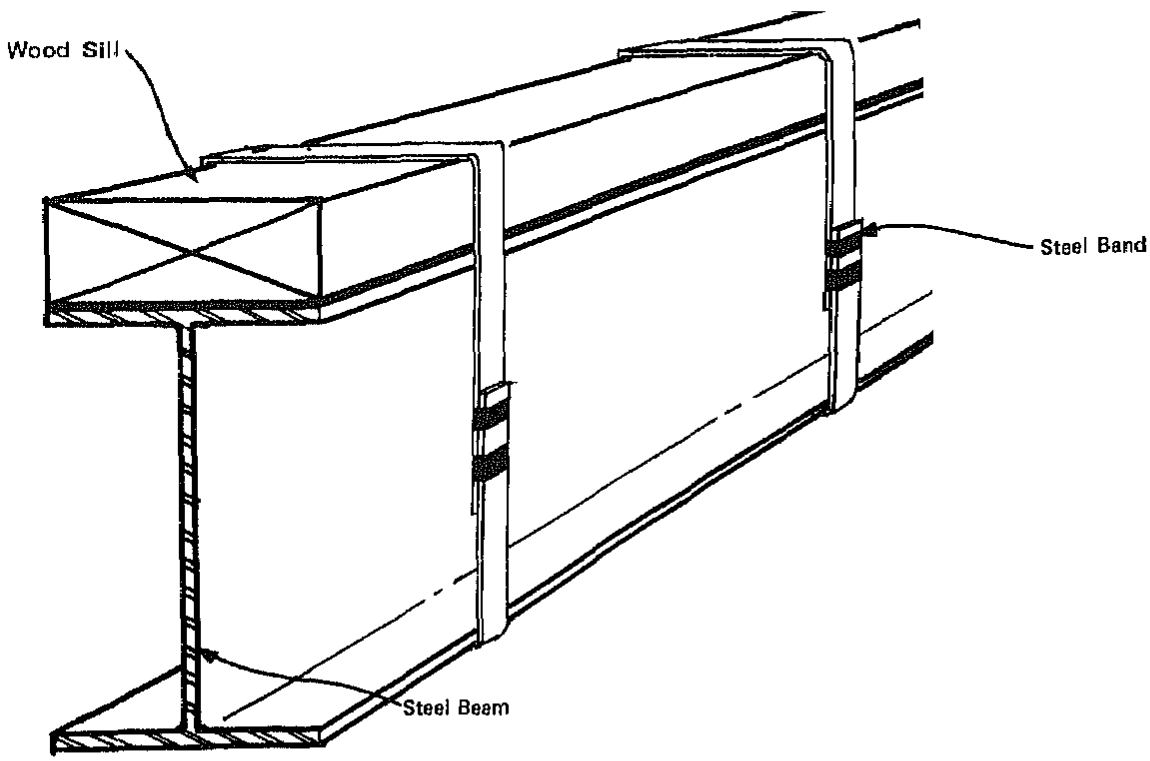


FIGURE 2.11
SILL PLATE ATTACHMENT TO STEEL BEAM

2.12 VOLUMETRIC MODULE JOINT DETAILS

Housing Manufacturers:

General Electric
Home Building Corp.
Hercules
Levitt
Material Systems
National Homes

Joining details for volumetric module construction must be designed to consider the dimensional tolerances of the modules and the foundation on which they are placed. By so doing, it is possible to complete connections in volumetric module erection where access is limited compared to that available in the conventional sequence of construction.

A number of innovative details have been developed by Operation BREAKTHROUGH producers to meet conditions unique to this type of construction. The typical erection sequence for the stacked module arrangement is shown in Figure 2.12a along with four common joint details which are illustrated.

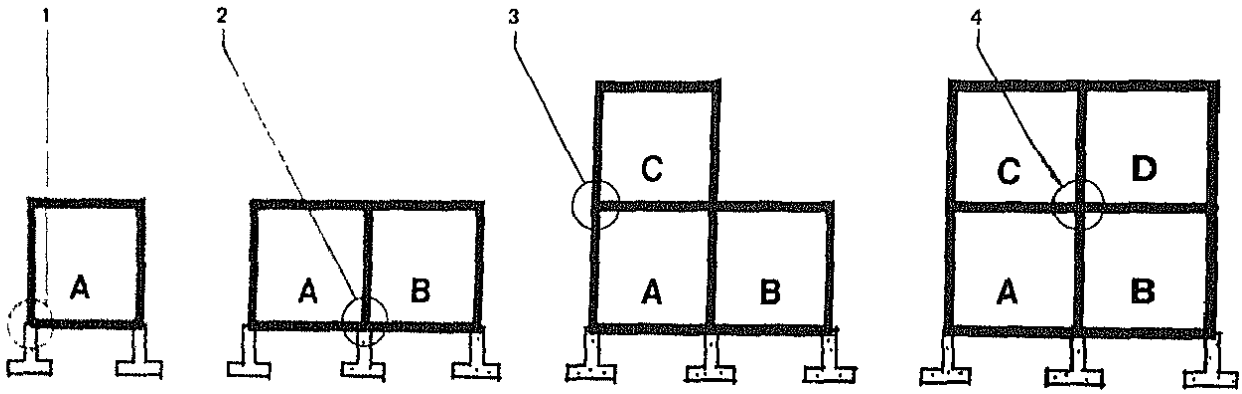


FIGURE 2.12a
TYPICAL STACKED MODULE ERECTION SEQUENCE

:terior Module to Foundation
int

is normally not a difficult
ection because of access both
l side the module and underneath
n the crawl space or basement.
pieces, often used to cover
s, come into play especially
l the connection is made on the
de of the module.

Hercules–Figure 2 12b

A 2x8 sill plate is attached to the foundation wall with anchor bolts cast into the concrete The 2x12 rim joist and 2x4 ledger strip of module A rest on the sill plate and are mechanically fastened to it with steel plates nailed in place.

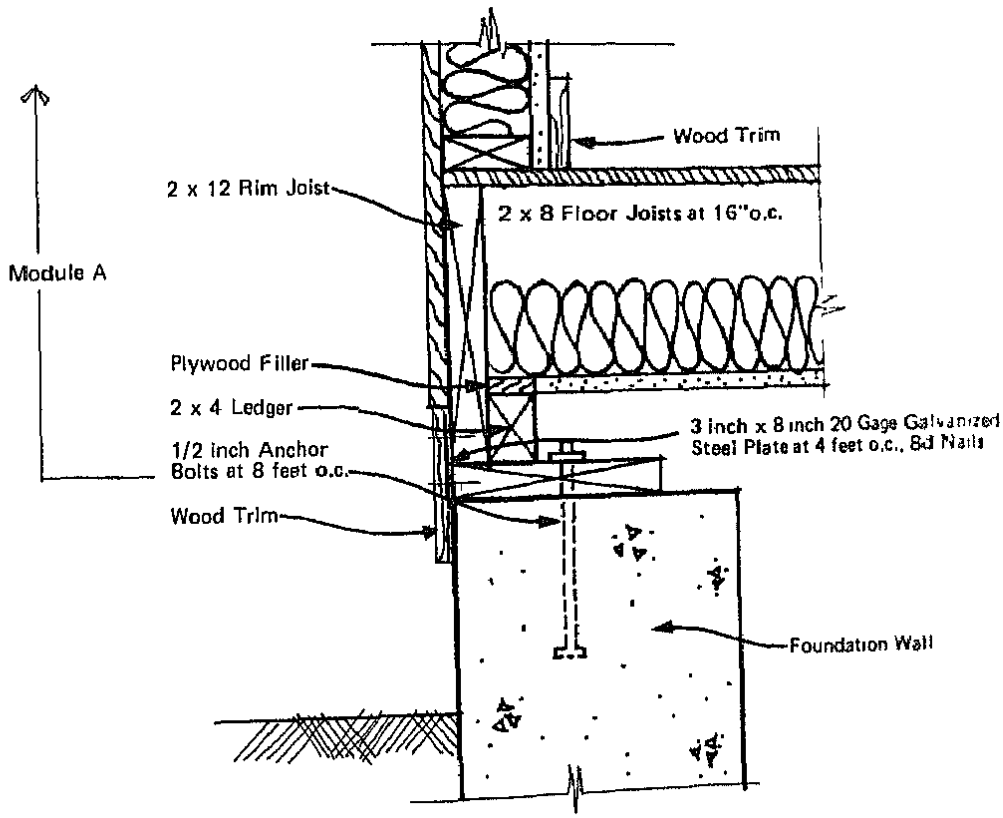


FIGURE 2.12b
HERCULES– EXTERIOR MODULE TO FOUNOATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

Material Systems–Figure 2.12c

A 2x8 sill plate and bent steel plates are attached to the foundation wall by anchor bolts. The module is positioned on the sill plate and attached to the steel plates with lag bolts. Access within the crawl space is required for this connection.

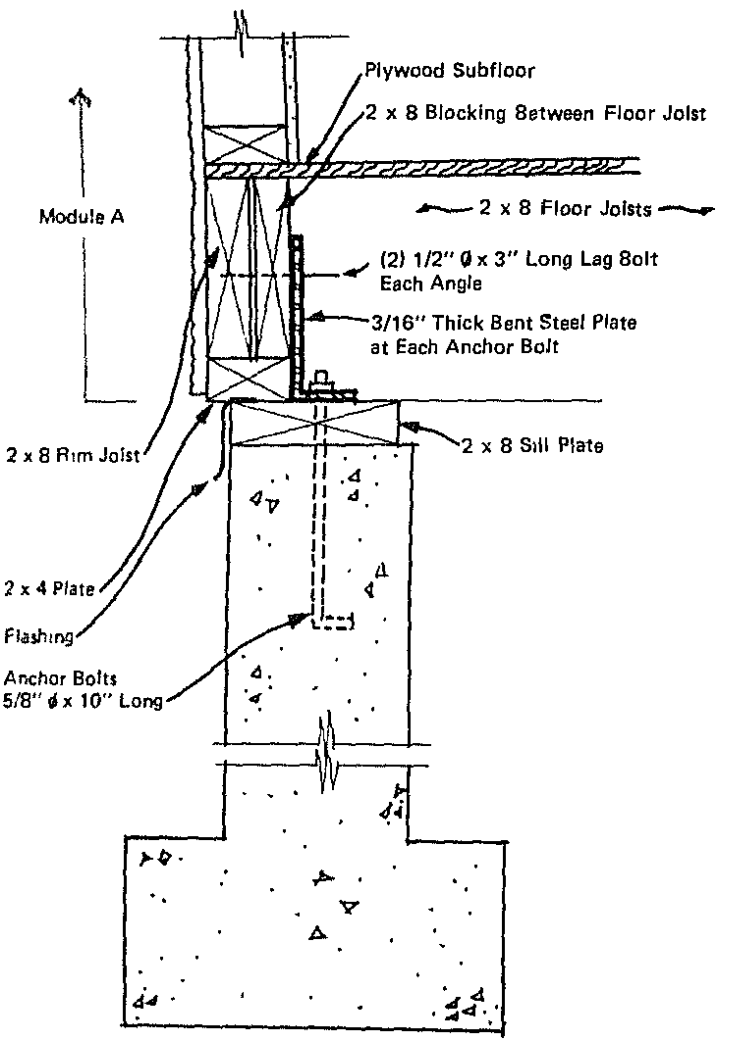


FIGURE 2.12c
MATERIAL SYSTEMS–EXTERIOR MODULE TO FOUNDATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

Home Building Corp.—Figure 2.12d

Concrete foundation wall is cast with a continuous 2x3 wood ledger and steel straps which protrude from the top. The module is placed on the wall and the straps are nailed to the 2x6 rim joist. Nailing requirements depend on strap spacing.

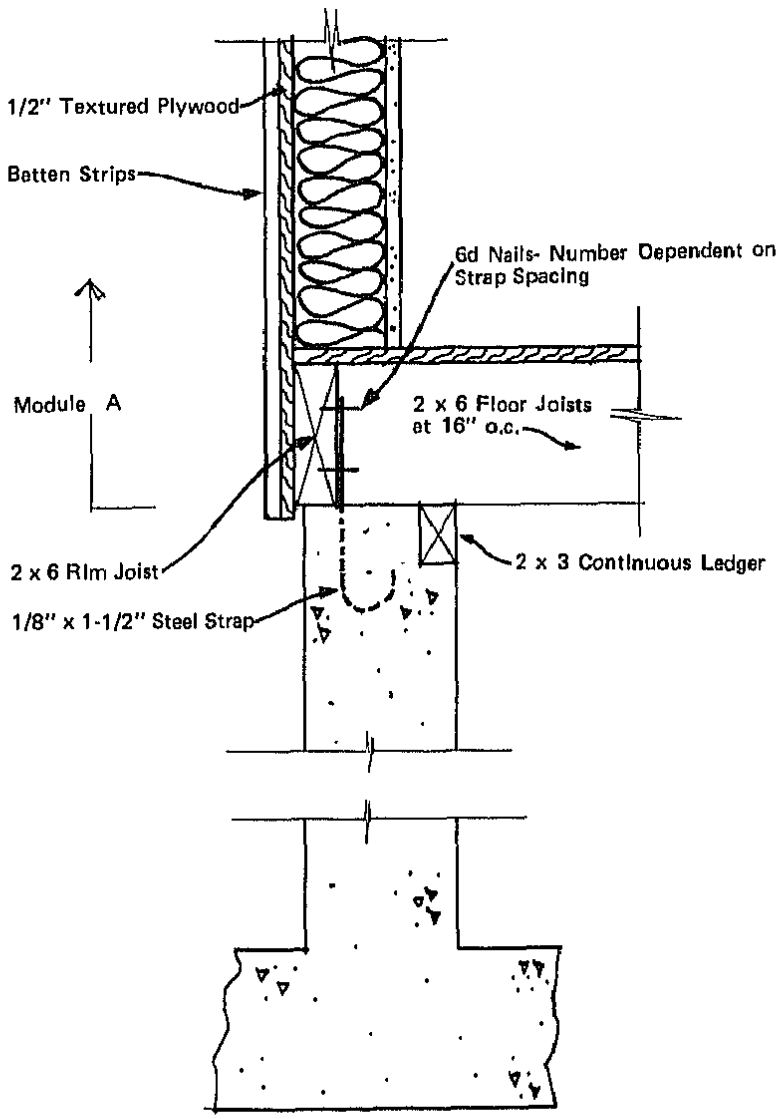


FIGURE 2.12d
HOME BUILDING CORPORATION—EXTERIOR MODULE TO FOUNDATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

2. Interior Module to Foundation Joint

The two lower modules of a stacked configuration normally have a common interior foundation support. Typically, this could be a concrete wall, a masonry wall, a precast grade beam, or a pipe column. The positioning of module B after module A could make connection difficult because of limited access.

Hercules–Figure 2.12e

Steel pipe columns are used to support modules A and B in the basement of single family attached dwellings. A 2x8 is attached with lag screws to the steel cap plate at the top of the pipe column. Module A is positioned on the 2x8 and connected with galvanized steel plates. Insulation is fastened to the 2x12 rim joist of module A and module B is then lowered into place and connected to the pipe column.

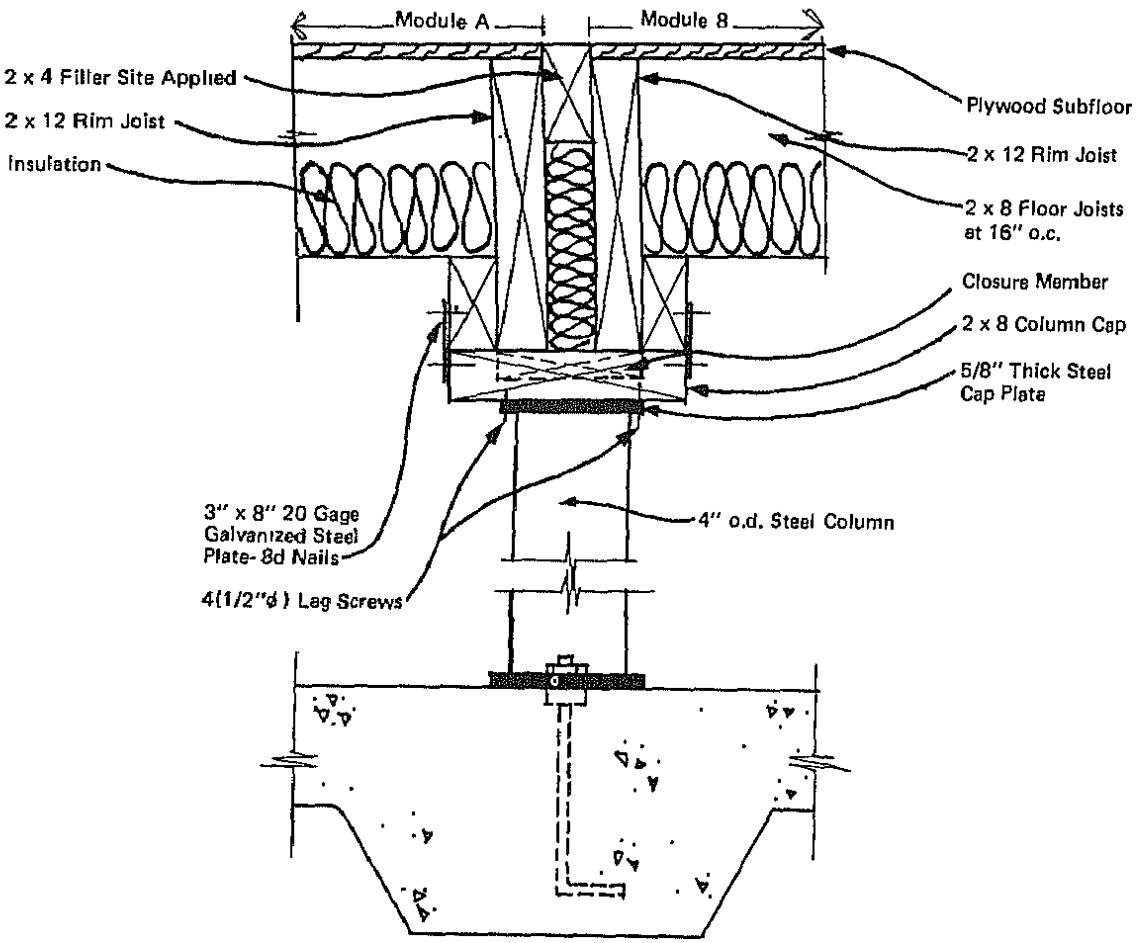


FIGURE 2.12e
HERCULES– INTERIOR MODULE TO FOUNDATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

Material Systems—Figure 2.12f

A 2x8 sill plate and steel brackets are attached to the foundation wall with anchor bolts. Modules A and B are positioned with the 2x4 subplates resting on the foundation sill. The brackets are bent up and attached to the rim joists with lag bolts.

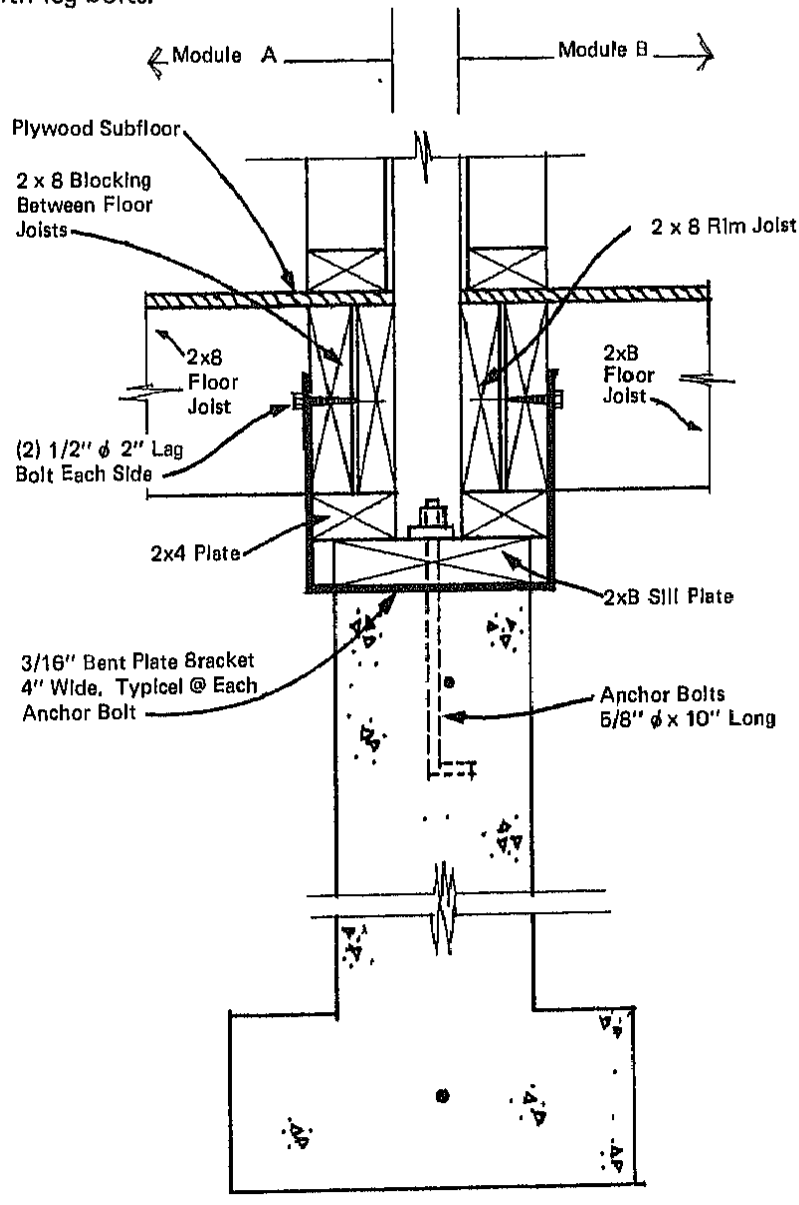


FIGURE 2.12f
MATERIAL SYSTEMS INTERIOR MODULE TO FOUNDATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

General Electric—Figure 2.12g

A steel plate is attached to the foundation wall with anchor bolts. Each module is lowered into place and steel angles are fastened to the 2x10 rim joists. The angles are then bolted to the steel plates which have slotted holes to accommodate dimensional variations.

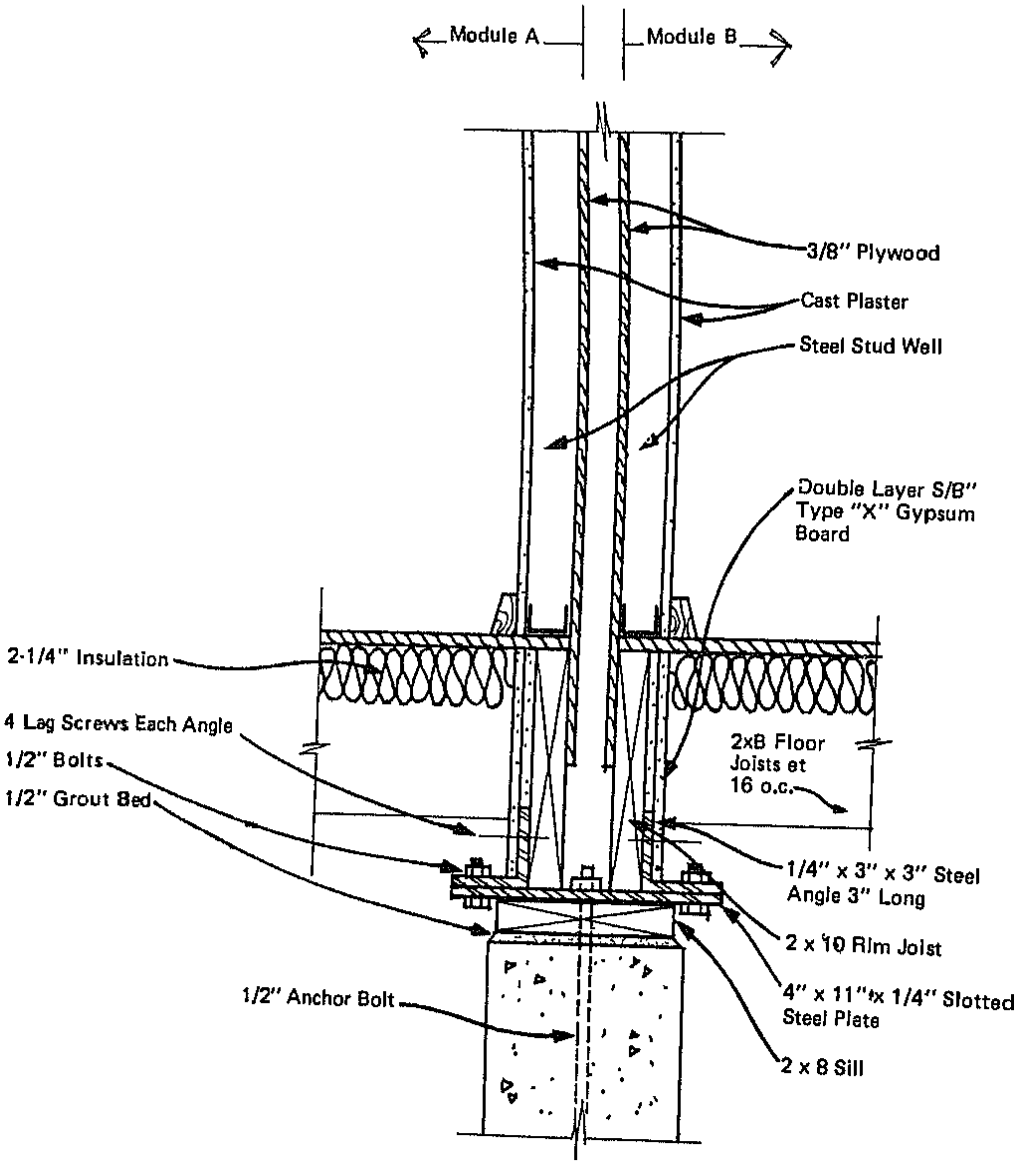


FIGURE 2.12g
GENERAL ELECTRIC– INTERIOR MODULE TO FOUNDATION DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

3. Exterior Module to Module Joint

When modules are stacked one upon the other, the ceiling is contained in the lower module and the floor in the upper module with an air space between. The structural connection between modules must be made from outside since access is generally not possible within the floor/ ceiling assembly.

Levitt—Figure 2.12h

The ceiling of module A is constructed of 2x4's at 16 inch centers attached to a composite rim joist (2x10 next to a 2x8). The floor of the upper module is constructed of 2x8's at 16 inch centers attached to rim joists consisting of a 2x10 next to a 2x12. The resulting offset allows a lap mating of the two modules. Nailing through the 2x10 of module A into the 2x12 of module C provides the structural attachment. A fascia trim piece is then added to conceal the joint.

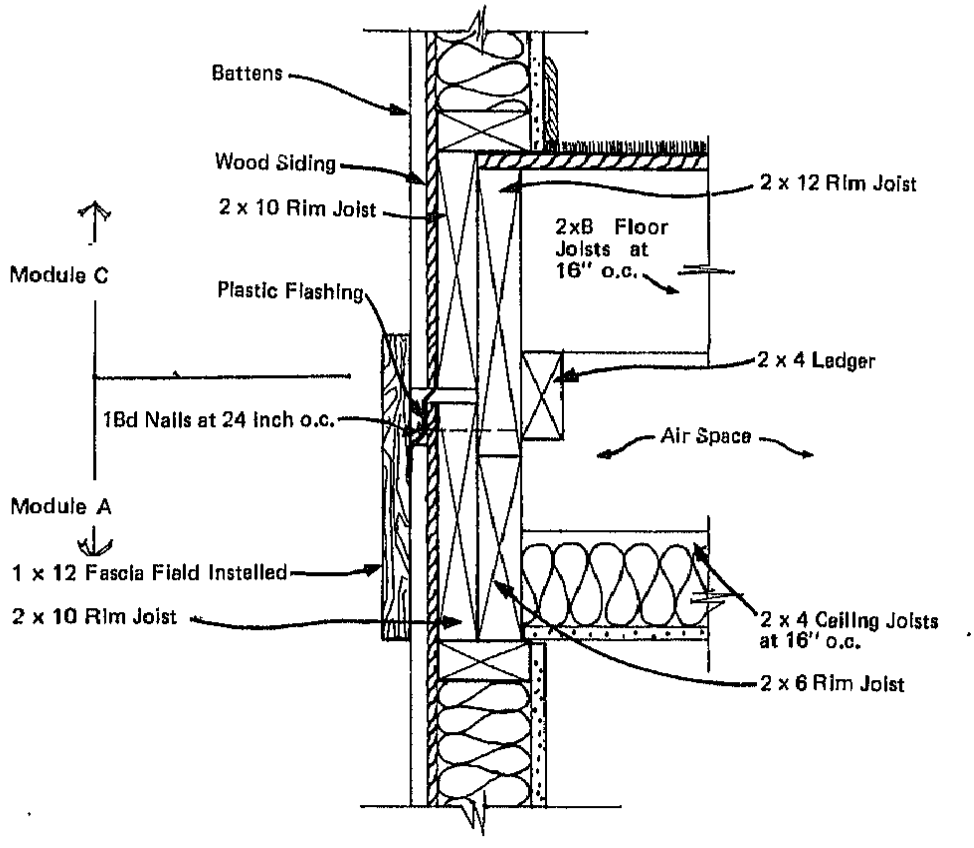


FIGURE 2.12h
LEVITT– EXTERIOR MODULE TO MODULE DETAIL

2.12 VOLUMETRIC MODULE JOINT DETAILS
continued

Hercules– Figure 2.12i

The ceiling of module A is constructed of 2x6's at 16" centers attached to a 2x6 rim joist. The floor of module C consists of 2x8's at 16" centers attached to a 2x12 rim joist and a 2x4 sill member. Mechanical joining of the modules is accomplished with prepunched galvanized steel plates attached by nailing.

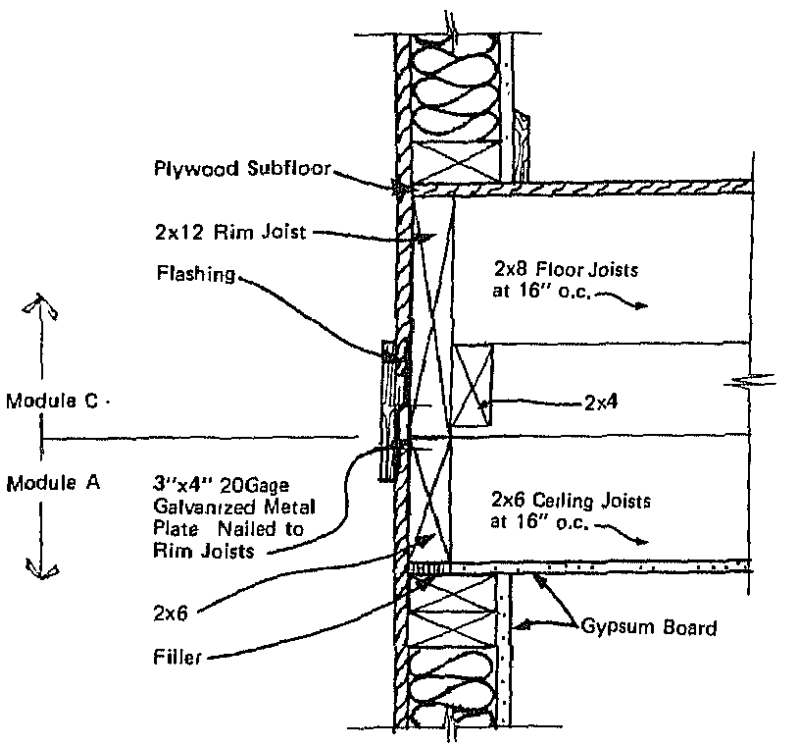


FIGURE 2.12i
HERCULES– EXTERIOR MODULE TO MODULE DETAIL

4. Interior Module to Module Joint

The stacked module arrangement presents a special problem in structurally connecting module D to the other three modules. As has been illustrated, modules A,B and C can normally be attached to each other. However, the positioning of module D does not allow the required access and other methods must be considered. Fire and acoustical considerations compound this joining problem.

National Homes–Figure 2.12j

The erection sequence illustrates a solution using adhesives. Module A is positioned and insulation is attached to the 2x12 rim joist. After module B is lowered into place, a continuous 1x8 wood tie is nailed to each 2x12. The 2x8 rim joist of module C is placed on the tie and fastened by nailing. A continuous bead of adhesive is placed on the wood tie and module D is positioned with its 2x8 rim joist in contact with the adhesive.

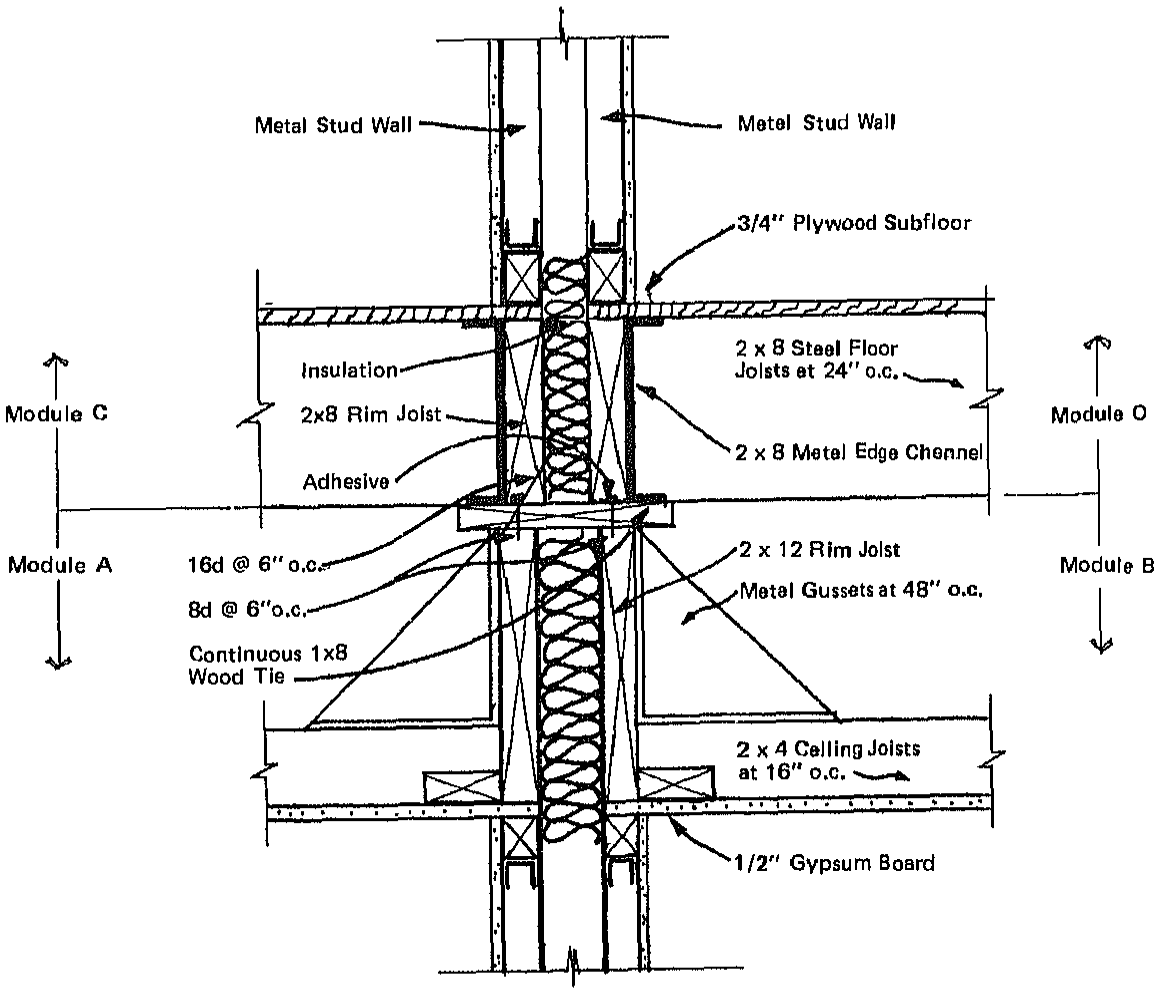


FIGURE 2.12j
NATIONAL HOMES– INTERIOR MODULE TO MODULE JOINT

2.13 FOUNDATION WALLS ARE SURFACE BONDED MASONRY

Housing Manufacturer:
Boise Cascade

One of the problems in today's construction industry is that of getting skilled labor, especially in outlying locations. Another is the rising cost of field labor. One solution to these problems is to develop simpler, more rapid field building assembly processes.

For masonry block foundations, a system of surface bonding is used which eliminates conventional block mortar joints. The masonry units are simply stacked dry and a bonding coating troweled on both sides.

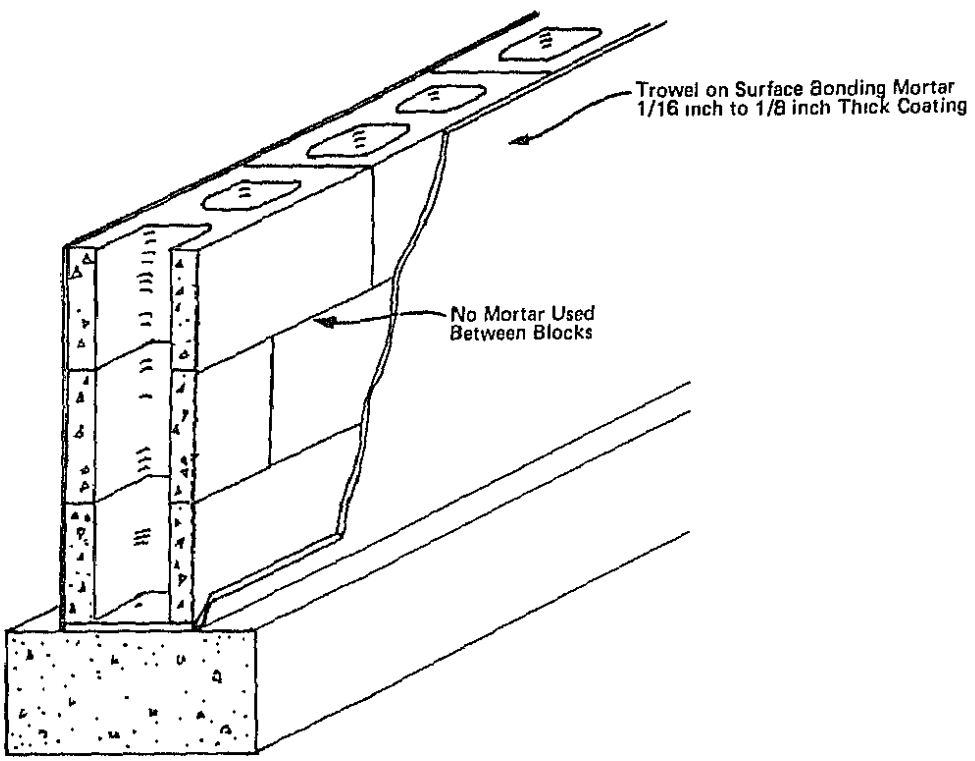


FIGURE 2.13
SURFACE BONDED FOUNDATION WALL

2.14 PRESTRESSED CONCRETE GRADE BEAM

Housing Manufacturer:
Material Systems

Because of the effects of adverse weather conditions, the construction of the building foundation can be a time-consuming constraint on the building process. This is especially true when the foundation is constructed of wet materials such as cast-in-place concrete.

Precast, prestressed concrete grade beam foundations used in this housing system can be constructed year around, even in cold climates, and can satisfy close tolerances required in industrialized buildings—Figure 2.14a.

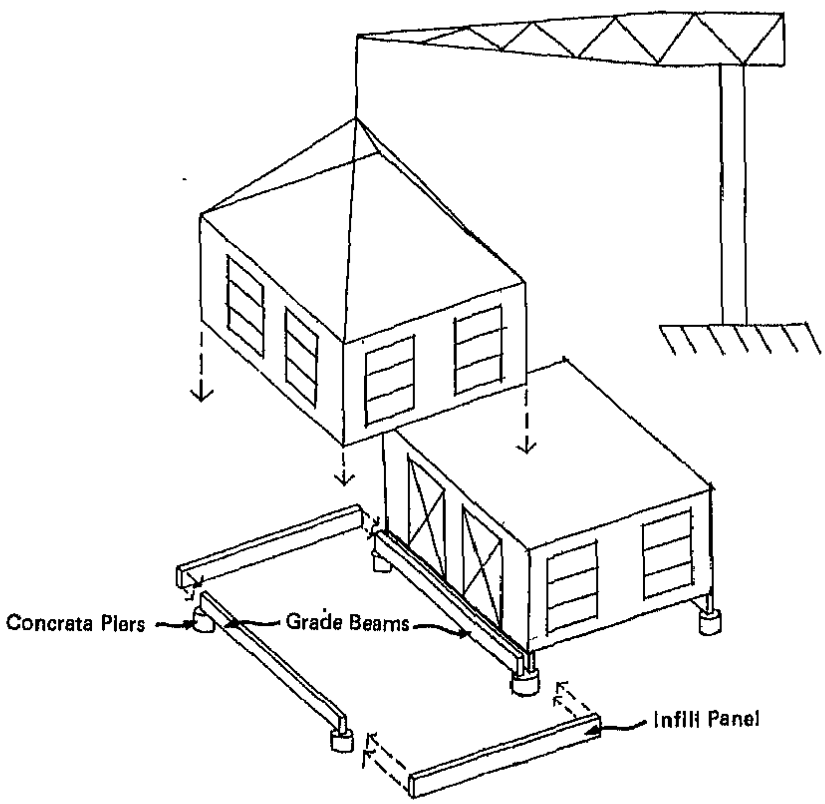


FIGURE 2.14a
ERECTION OF MODULES ON GRADE BEAM FOUNDATION

2.14 PRESTRESSED CONCRETE GRADE BEAM
continued

The grade beams bear on cast-in-place concrete piers and are connected by bolting to steel straps welded to reinforcing steel in the piers, Figure 2.14b. Modules are lowered to the grade beam and attached with steel straps and mechanical fasteners; straps are bolted to the grade beam and attached with lag bolts to the wood rim joists of the modules.

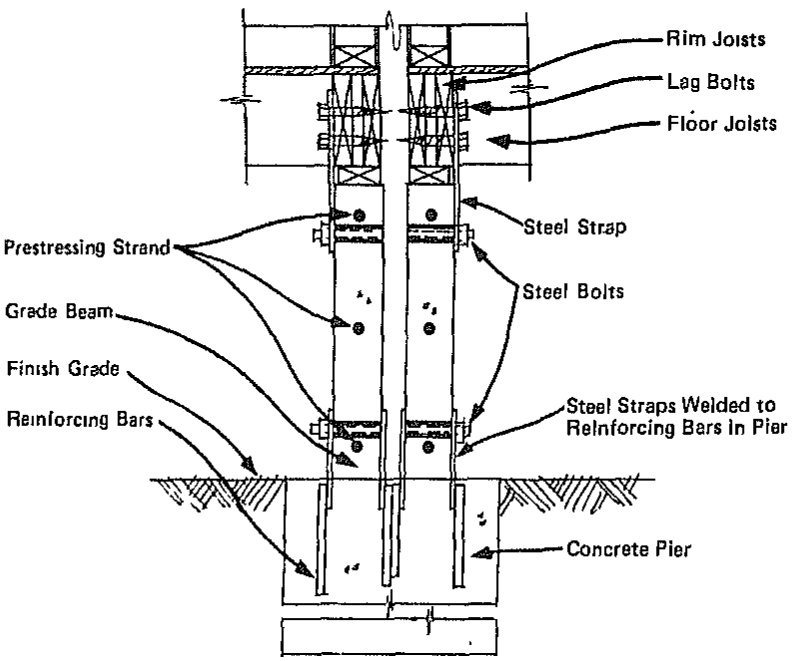


FIGURE 2.14b
GRADE BEAM CONNECTION DETAILS

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS

Housing Manufacturers:

- BSI
- Descon/Concordia
- FCE-Dillon
- Shelley

Prefabricated concrete systems present unique problems in field connecting structural components. The designer is always striving to make the field connections as simple, quick attaching and foolproof as possible. The details described below illustrate some solutions used in four OPERATION BREAKTHROUGH systems.

Descon/Concordia

This high-rise system of construction uses prestressed concrete floor panels which span between precast concrete bearing wall panels. See 2.17 for discussion of structural systems response to abnormal loading. Mechanical connections between elements are by a patented field friction bolting technique—Figures 2.15 a and b.

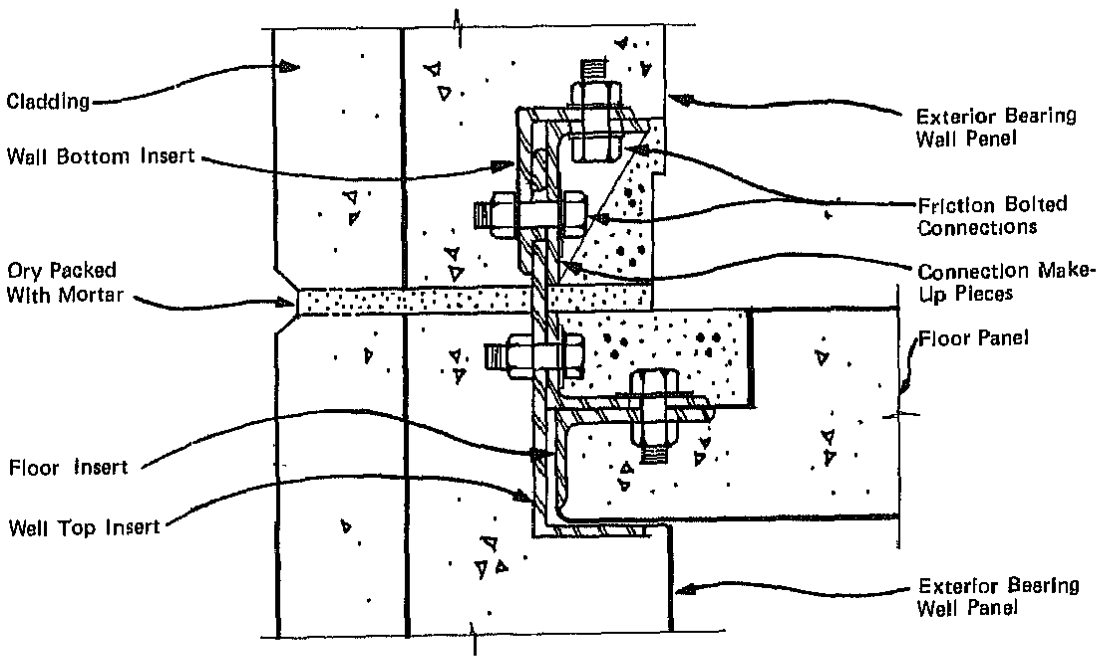


FIGURE 2.15a
DESCON/CONCOROIA— EXTERIOR WALL TO FLOOR CONNECTION

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS
continued

Steel inserts are embedded in the concrete panel and held in place by stud-welded anchor bolts. During erection when two such elements are placed adjacent to each other, a steel make-up piece is friction bolted to the embedded inserts to complete the connection. The make-up pieces are preslotted to take up manufacturing and erection tolerances.

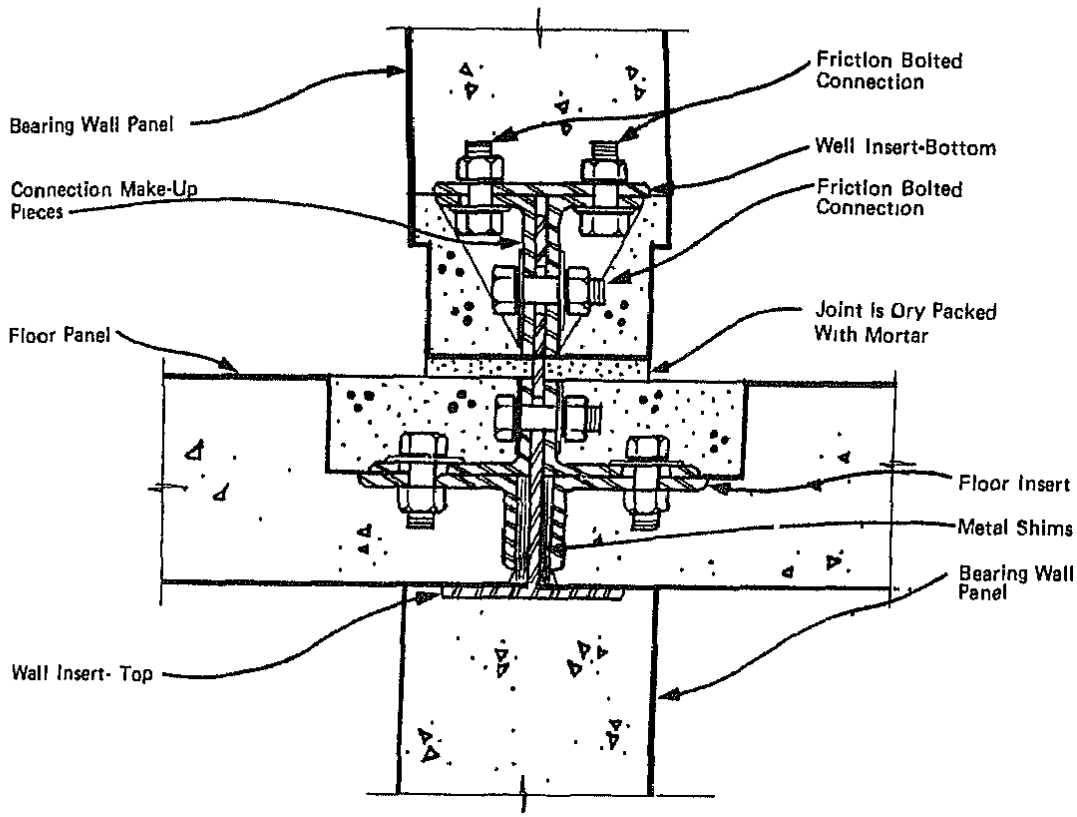


FIGURE 2.15b
DESCON/CONCORDIA– INTERIOR WALL TO FLOOR CONNECTION

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS
continued

BSI

This basic structural system is a series of precast concrete panels which are tied together with steel reinforced grouted joints.

Vertical wall panel joints are made by placing a steel connecting bar within the steel loops which project from the panel edges and then filling the joint with grout—Figure 2.15c.

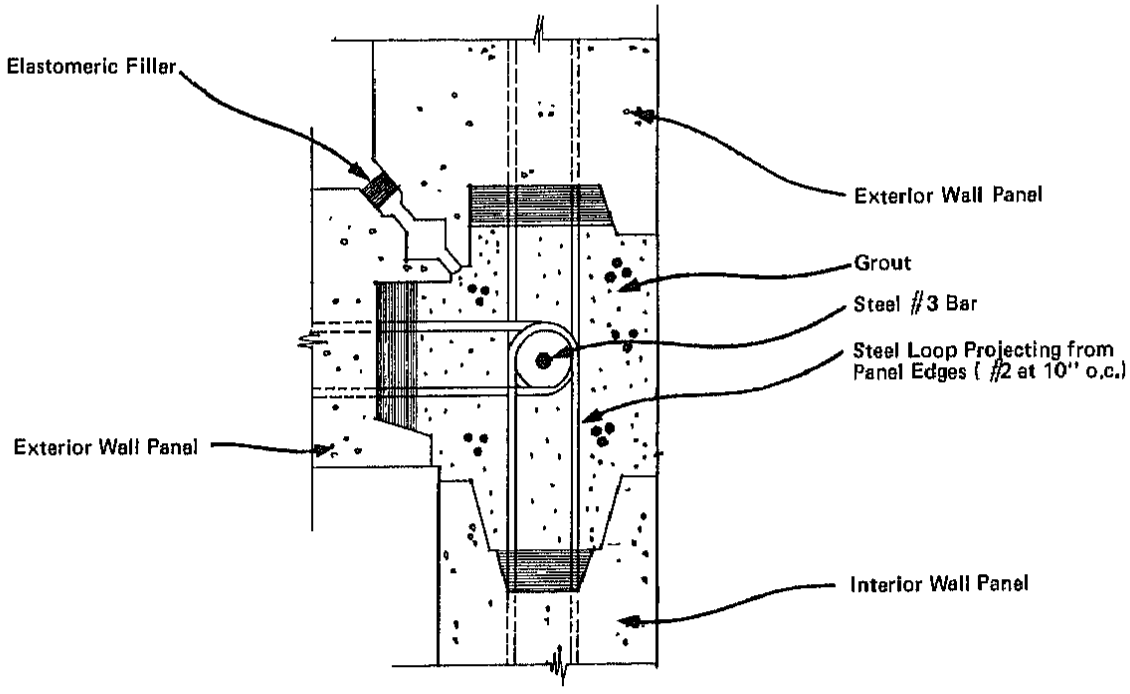


FIGURE 2.15c
BUILDING SYSTEMS INTERNATIONAL—VERTICAL EXTERIOR WALL JOINT

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS
continued

The typical horizontal wall to floor panel joint is made by tieing together steel loops protruding from the panels with continuous longitudinal steel bars. Prior to grouting the joint, the wall above is leveled with a leveling bolt cast into the lower wall–Figure 2.15d.

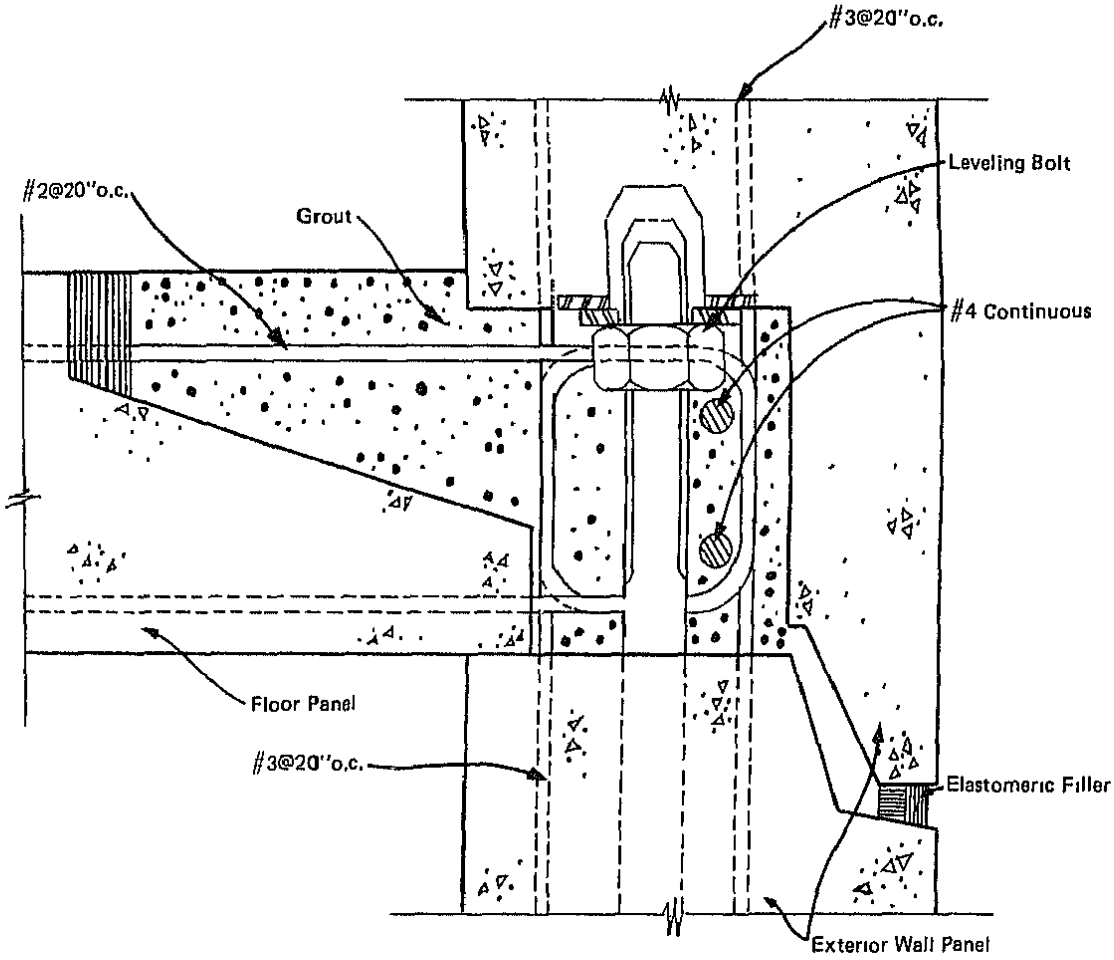


FIGURE 2.15d
BUILDING SYSTEMS INTERNATIONAL–EXTERIOR WALL TO FLOOR JOINT

FCE-Dillon

This building system combines precast concrete panels and cast-in-place concrete construction to obtain the required structural continuity. See 2.16 for a description of the erection procedure used in the system and 2.17 for the structural response to abnormal loading.

The precast floor slabs are prestressed concrete members cast in thicknesses of 4 inch, 6 inch, and 8 inch in lengths up to 32 feet.

Exterior bearing walls are precast concrete sandwich panels containing rigid insulation. Interior bearing walls have hollow core openings which are formed during the casting process. These voids serve two purposes: (1) they reduce the weight of the walls, facilitating transportation and handling, and (2) they play an important part in obtaining the structural integrity as discussed in 2.16.

The typical interior bearing wall joint is made with a combination of cast-in-place concrete and steel reinforcement—Figure 2.15e. The 4 inch thick floor slabs are placed on the lower hollow core wall, the steel reinforcement is placed and concrete is poured into the wall cores and onto the slab to provide a total floor thickness of 8 inches. The upper wall is lowered into position and the procedure of pouring concrete from above is repeated.

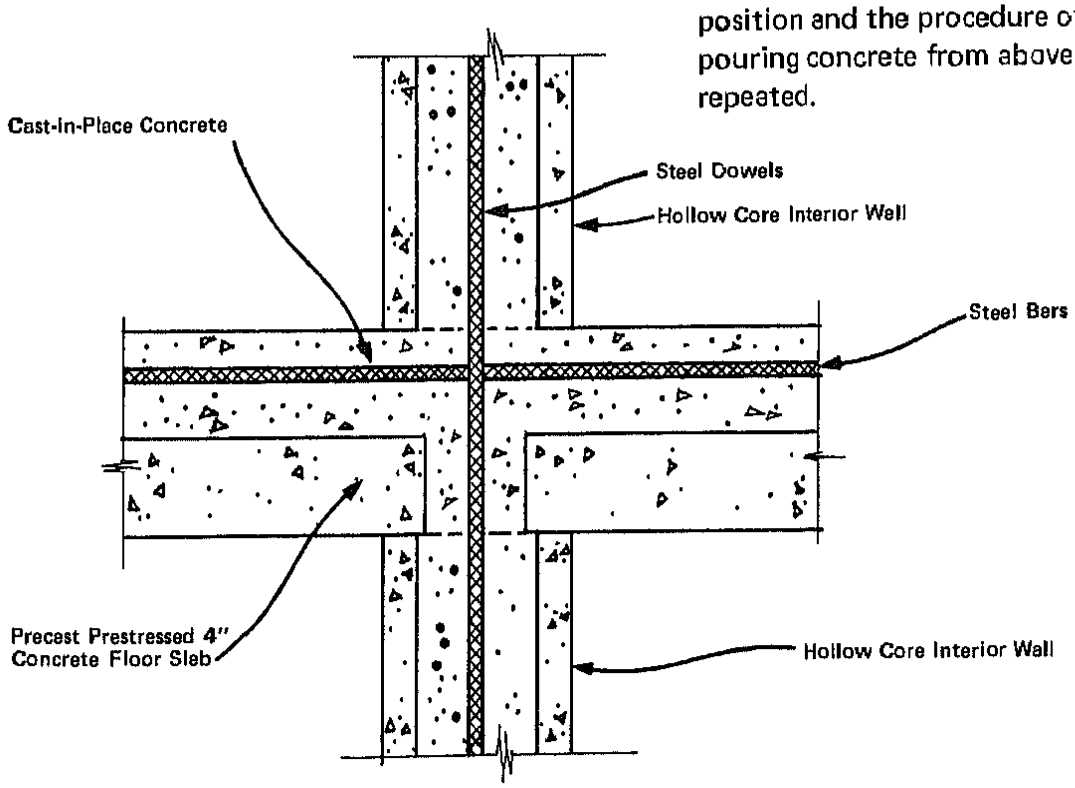


FIGURE 2.15e
FCE-DILLON– INTERIOR BEARING WALL DETAIL

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS
continued

The typical exterior wall joint is made with a combination of cast-in-place concrete, steel reinforcement and mechanical connection– Figure 2.15f. A threaded rod is screwed into an insert cast into the lower wall and then bolted to an angle embedded in the upper wall with stud welded anchor bolts. The floor slab is placed, steel bars are looped around the rod, the concrete topping is poured and the access pocket is drypacked with concrete to complete the joint.

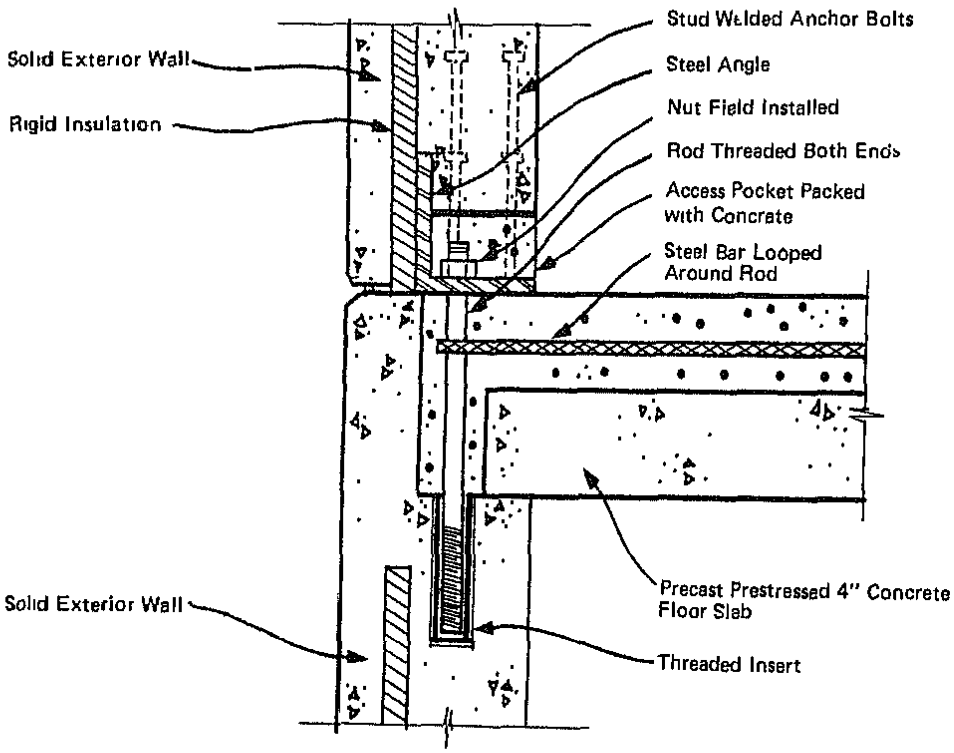


FIGURE 2.15f
FCE-DILLON– EXTERIOR BEARING WALL DETAIL

2.15 CONCRETE BUILDING SYSTEM JOINT DETAILS
continued

Shelley

The precast concrete volumetric modules used in this system contain columns integrally cast with the wall (see 1.2). Four columns occur in each wall allowing the remainder of the wall to be non-load-bearing and open for room-to-room access if necessary—Figure 2.17a.

The columns contain vertical ducts in which steel dowels are grouted to provide structural continuity—Figure 2.15g. Bearing pads can be either neoprene, steel plate with grout or a neoprene-steel sandwich, depending on design conditions. The neoprene bearing pad provides the additional benefit of sound attenuation between modules.

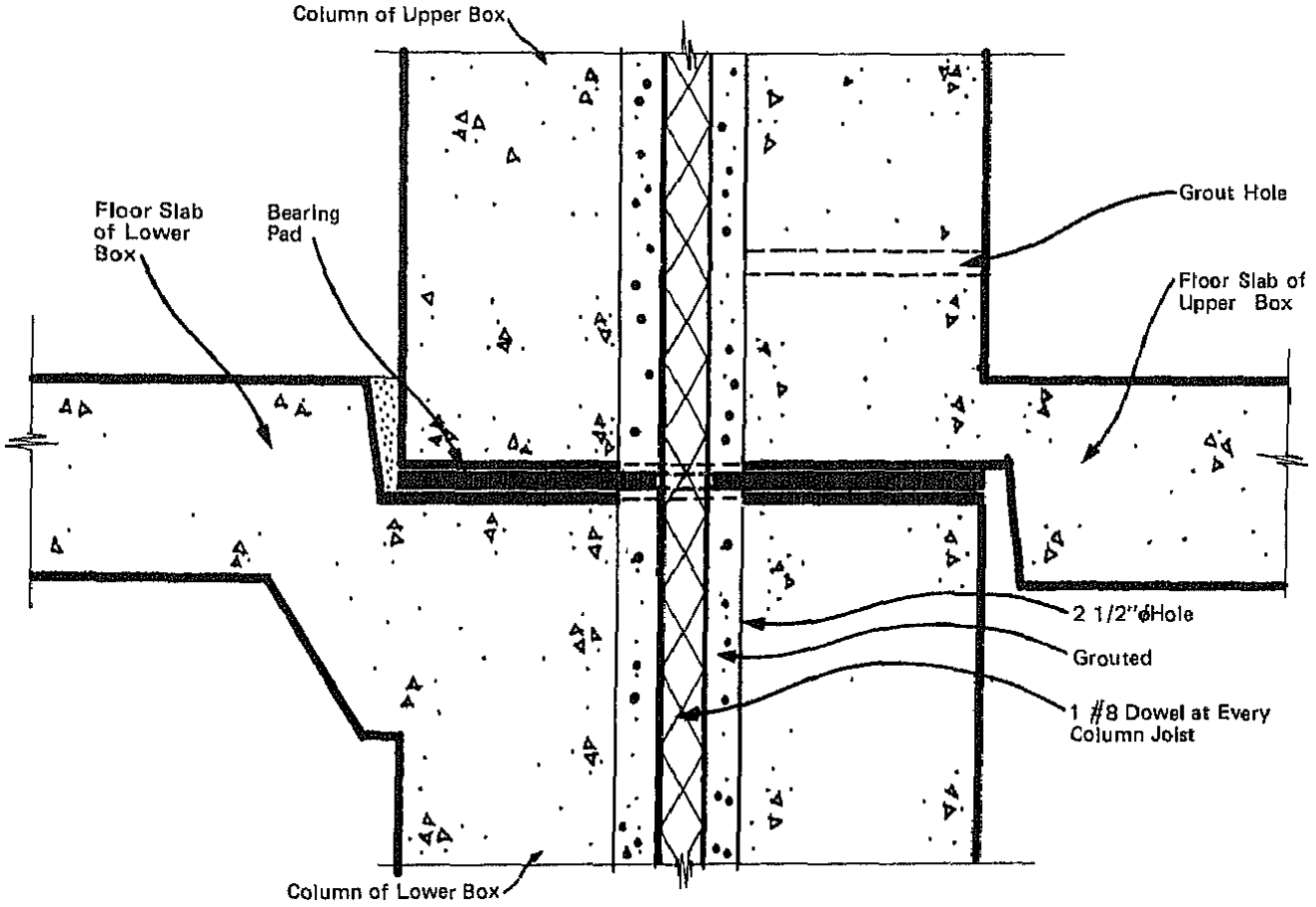


FIGURE 2.15g
SHELLEY – COLUMN TO COLUMN JOINT

2.16 ASSEMBLY/ERECTION PROCEDURE SPEEDS BUILDING CONSTRUCTION

Housing Manufacturer:
FCE-Dillon

The Dillon system's erection procedure is based on a production flow concept which results in a predictable and rapid building process. The erection sequence is such that each apartment building is assembled in a fixed order, as follows:

1. Foundation and first floor walls are cast-in-place concrete construction.
2. Mechanical core module with an 8 inch thick floor slab is set in place on top of the first floor walls and aligned (see 6.4 for description of mechanical core module).

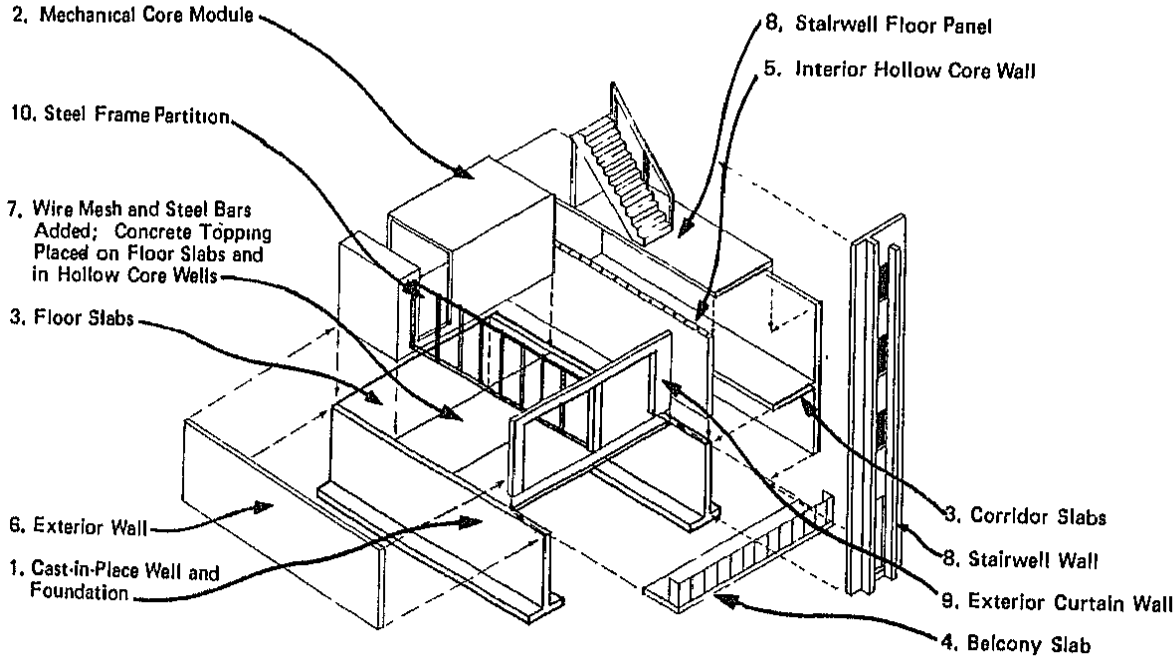


FIGURE 2.16
SCHEMATIC OF ERECTION PROCEDURE

2.16 ASSEMBLY/ERECTION PROCEDURE SPEEDS BUILDING CONSTRUCTION *continued*

3. The 4 inch thick prestressed concrete floor slabs and the 8 inch thick corridor panels are set on the walls and tied in place with steel rods which are inserted into both the base of the mechanical core module and into the supporting bearing walls.
4. The 8 inch thick balcony slab is set in place, braced, and tied to the building with steel rods.
5. The interior hollow core bearing walls are positioned adjacent to the corridor and braced laterally.
6. The solid exterior walls are positioned and braced laterally.
7. Wire mesh and steel bars are laid over the deck slabs. Concrete is placed to raise the floor to the 8 inch thickness of the mechanical core module and balcony slabs and is pumped into the wall cores, bonding the walls and floor into a continuous unit. Hollow core walls and deck slabs are used as forms for the cast-in-place concrete, creating a monolithic structure.
8. Stairwell wall and floor panels are added.
9. Exterior curtain wall panels are erected at balcony.
10. Steel frame partitions are erected.
11. The erection procedure described above is repeated for each floor of the building.

Once a story is erected, the electrical service in the prewired modules are connected to the building service. Likewise, the remaining utilities—domestic hot and cold water, range and bathroom ventilation, heating and air conditioning piping, telephone, cable for CATV and other communications systems—can be connected. This procedure allows for systematic utility installation and easy inspection of connections. A precast elevator module (see 8.1) and a mechanical penthouse (see 5.6) are also part of this system.

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE

Housing Manufacturers:

- BSI
- CAMCI
- Descon/Concordia
- FCE-Dillon
- Rouse Wates
- Shelley

OPERATION BREAKTHROUGH producers were required to design high-rise buildings to ensure that progressive collapse would not result if a structural element or a prescribed combination of elements were rendered incapable of carrying the load. This criterion was included because several localized failures of elements in tall buildings have caused collapses resulting in loss of lives.

Abnormal loading has generally caused the failure of critical elements which resulted in structural collapse. The major source of high local overload is explosive forces within or external to the structure. Some sources of explosives are service system failures and bombings. Accidential impact due to highway vehicles, construction equipment and aircraft and faulty design and construction are other possible sources of abnormal loadings.

The criterion provides two design methods, either of which or a combination of the two can be used to show that progressive collapse would be prevented.

A. Alternate Path Approach

If a critical building element or specified combination of elements are removed accidentally, alternate load paths are provided such that only a limited portion of the structure is damaged.

B. Local Resistance Method

Critical elements can be designed to remain in place under abnormal loading which for design purposes is assumed to be 720 psf (5 psi). This static loading is assumed to approximate the force resulting from a gas explosion.

Imaginative design concepts were used by the six producers of high-rise structures to show compliance with the progressive collapse criterion.

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

Shelley—Figure 2.17a

Factory-produced concrete modules are stacked one upon another in a checkerboard pattern. See 1.2 for a description of the building system. Boxes overlap to provide matching of vertical columns which carry all gravity loads to the foundation.

Walls are designed to be non-load bearing. The occurrence of an abnormal loading within a module could cause failure of walls, floor and ceiling enclosing the space but the columns and beams would remain in place.

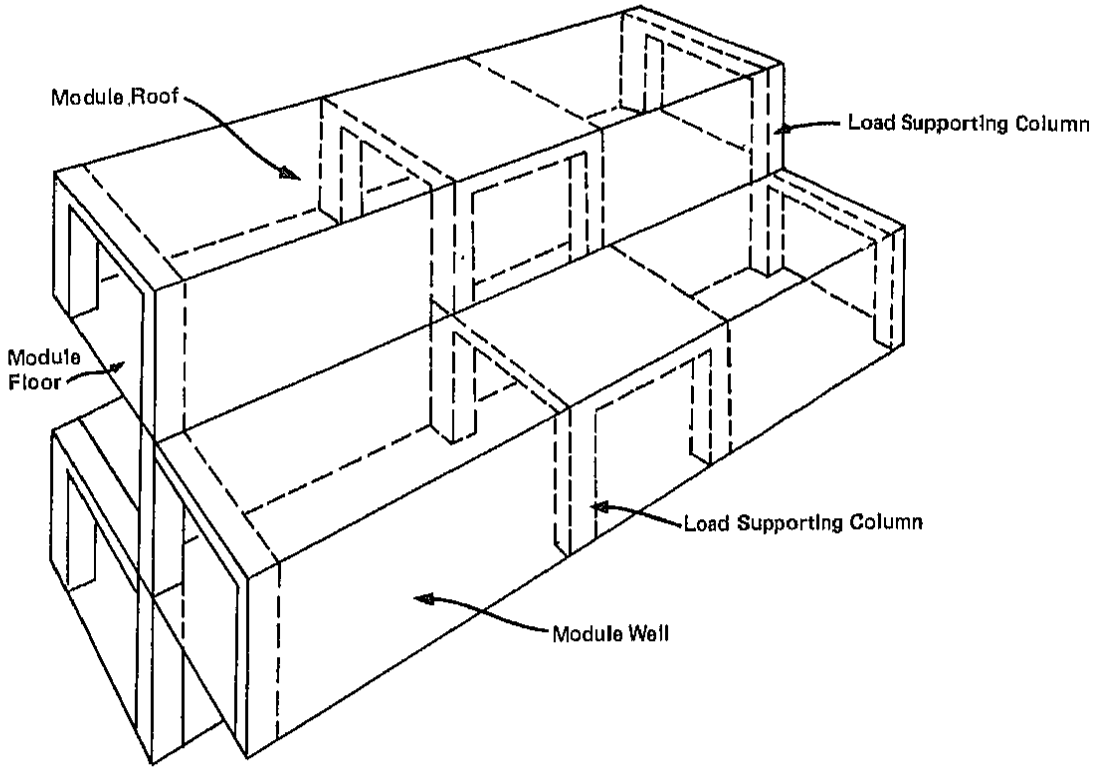


FIGURE 2.17a
SHELLEY—VERTICAL ALIGNMENT OF MODULE COLUMNS

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

Rouse Wates–Figure 2.17b

This building system utilizes 7 inch thick precast concrete walls and 8 inch thick precast concrete floors which are designed as simply supported members on a typical span of 22 feet. Joint design incorporating overlapping steel reinforcement and grout achieves continuity between panels.

The structure is designed to be self-supporting on removal of critical panels by providing alternate load paths. If a component can not be removed without causing progressive collapse, it is designed to remain in place when its tributary area is subjected to 720 psf force.

In response to the explosive loading, wall FH is designed to remain in place by the use of special panel and joint reinforcement. Interior wall EG will fail. Elements above will not fail since wall AC is designed to cantilever from the corridor. Some of the floor panels GH are designed as strong panels to resist 720 psf and remain in place to provide lateral support to walls FH, LK and IJ.

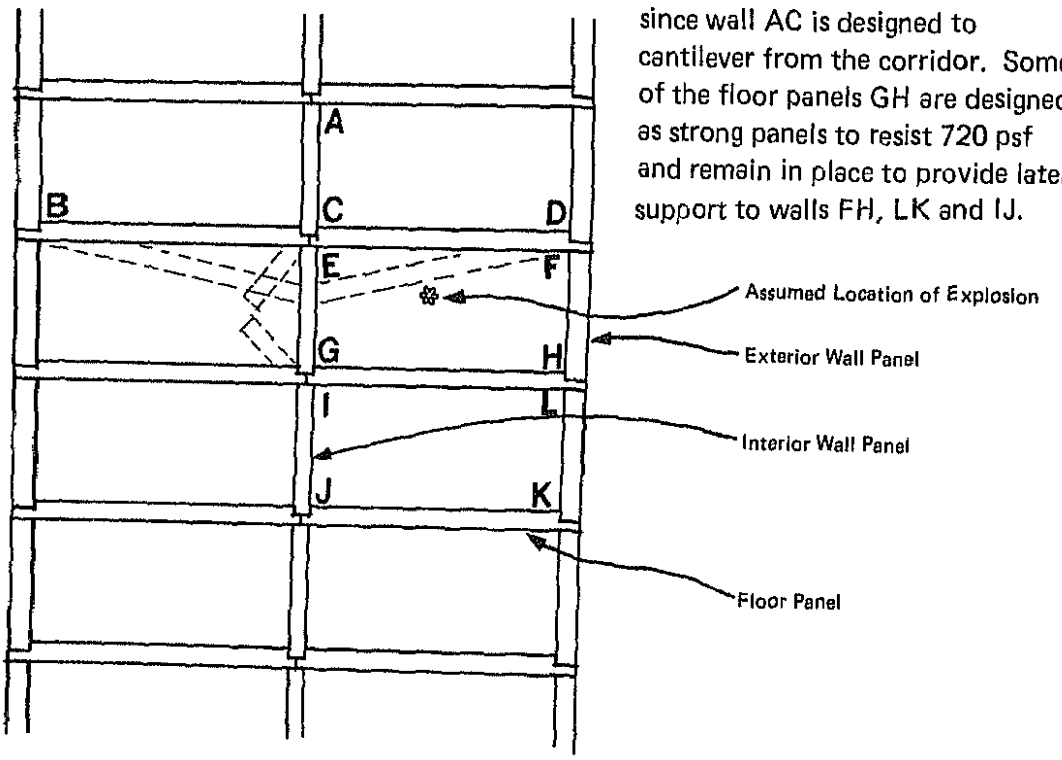


FIGURE 2.17b
ROUSE WATES– RESPONSE TO ABNORMAL LOAD

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

FCE-Dillon—Figure 2.17c

A combination of precast concrete panels and cast-in-place concrete is used to obtain structural continuity. See 2.16 for a description of the building system and 2.15 for typical joint details. The typical floor panel CD is designed to span the 32 feet between walls without midspan support. The steel frame partitions, in addition to functioning as room separators, are designed to resist vertical forces resulting from abnormal loading.

In response to an abnormal load in the location shown, partition EF will fail laterally. Wall DK will remain in place since it is designed to resist 720 psf by the addition of steel reinforcement. Floor slab GH will also remain intact because of additional reinforcement and vertical support provided by partition IJ. Similarly, floor slab CD remains after application of upward 720 psf force because of resistance of partition AB.

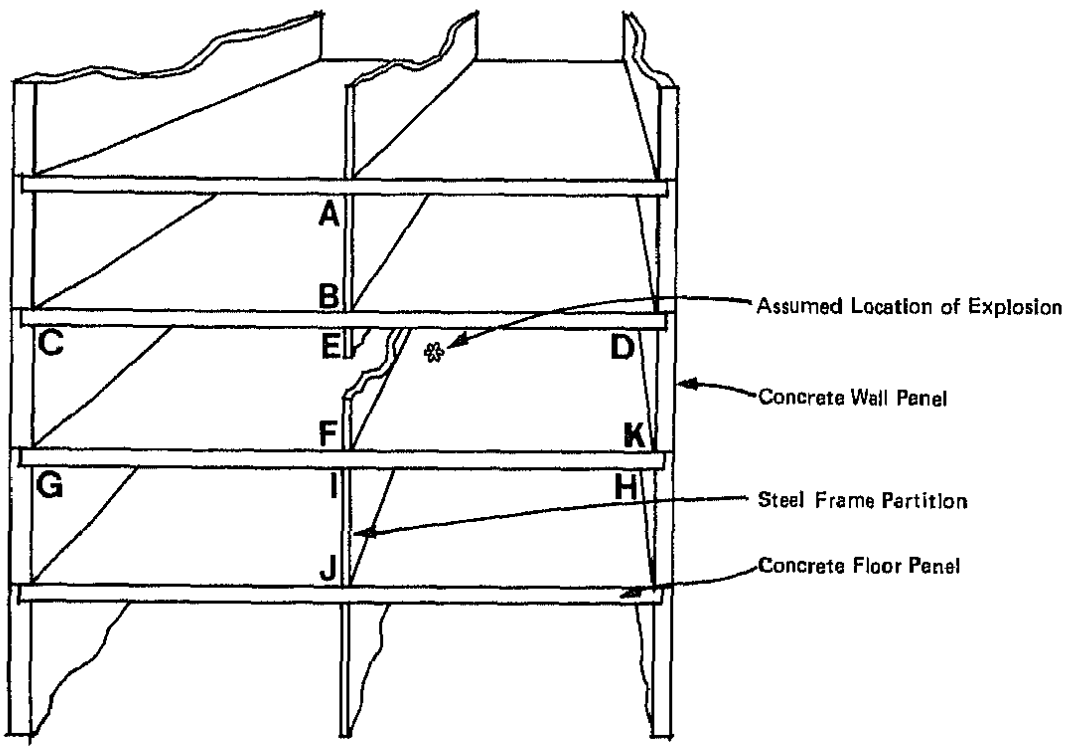


FIGURE 2.17c
FCE-DILLON– RESPONSE TO ABNORMAL LOAD

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

Descon/Concordia—Figure 2.17d

The structural system is constructed of 6½ inch prestressed concrete floor panels with a span of 22 feet supported on 8 inch precast bearing walls. Shear walls provide the necessary rigidity in the longitudinal direction.

In response to an abnormal load in the location shown, bearing walls AB and DC will remain in place when subjected to 720 psf. This is accomplished by the addition of steel reinforcement to the wall panels and positive mechanical connections between bearing walls and adjacent floor slabs. See 2.15 for typical joint details used in this system. Floor slabs AD and BC contain strong zones which are additionally reinforced to remain in place at 720 psf loading and provide lateral support for the bearing walls.

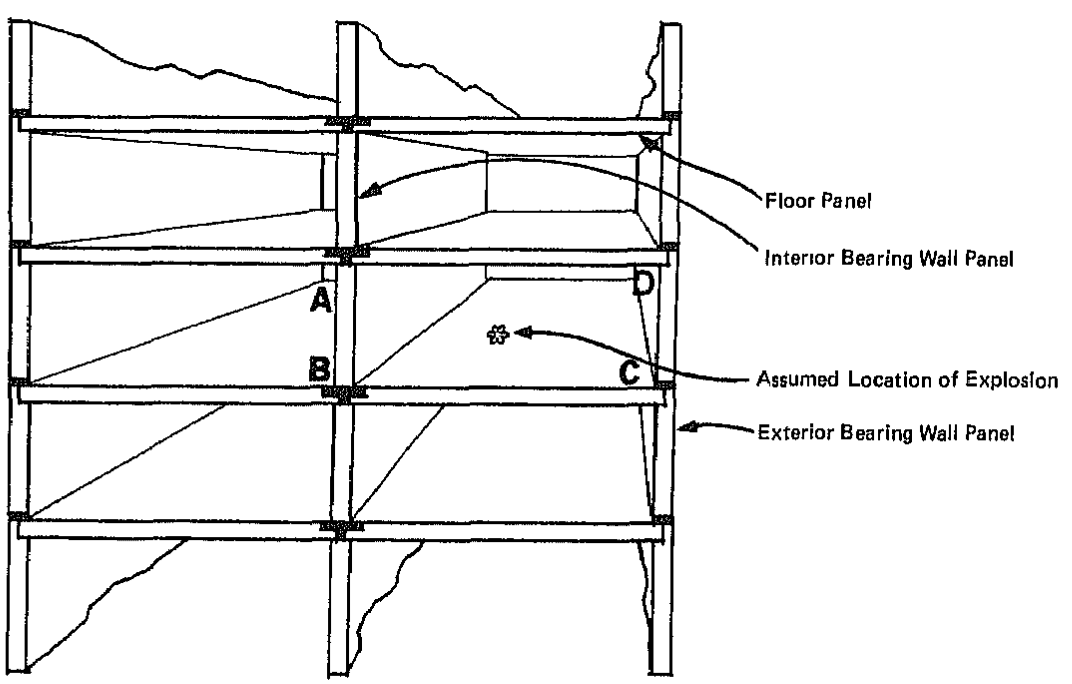


FIGURE 2.17d
DESCON/CONCORDIA— RESPONSE TO ABNORMAL LOAD

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

CAMCI—Figure 2.17e

This structural system is constructed of precast concrete cross walls, end walls, shear walls, floor panels and roof panels. Floor panels span 12 ft. 6 in. between walls. The longitudinal fascade walls are non-load bearing.

The alternate path method is used to show compliance with the progressive collapse criterion. Vertical joints between wall panels and horizontal joints between wall and floor panels are tied together by steel reinforcement and grout to provide structural continuity. The structure is designed to bridge openings caused by failure of a corner end wall panel as illustrated, any other wall panel or other elements of the primary structural support system.

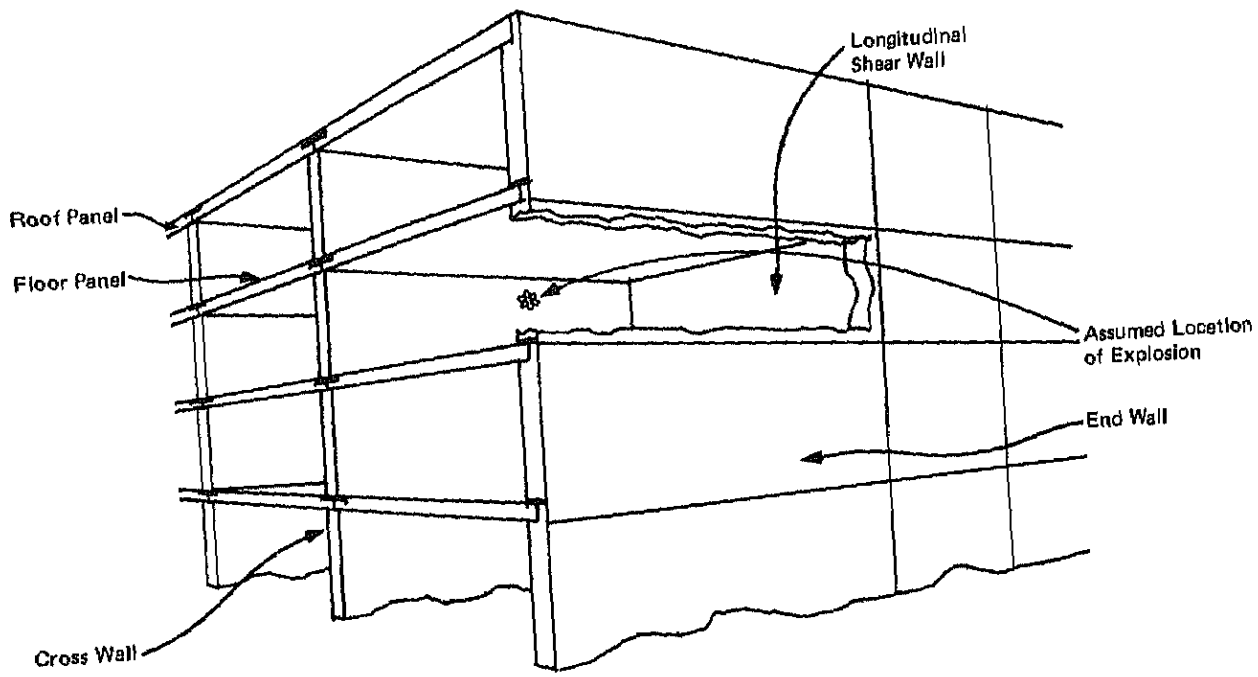


FIGURE 2.17e
CAMCI—CORNER PANEL REMOVED BY ABNORMAL LOADING

2.17 STRUCTURAL DESIGN TO PREVENT PROGRESSIVE COLLAPSE
continued

BSI—Figure 2.17f

The basic structural system is a series of precast concrete panels which are tied together with grouted joints containing overlapping steel reinforcement. See 2.15 for typical joint details. Load bearing interior and exterior wall panels are combined with floor and roof slabs. Floor slabs are supported by wall panels on a typical span of 12 ft. 6 in.

Generally, the alternate path approach is used to insure that progressive collapse is prevented if critical elements of the primary structural support should fail. In a few situations, alternate load paths are not available so critical members were designed to resist 720 psf without failure.

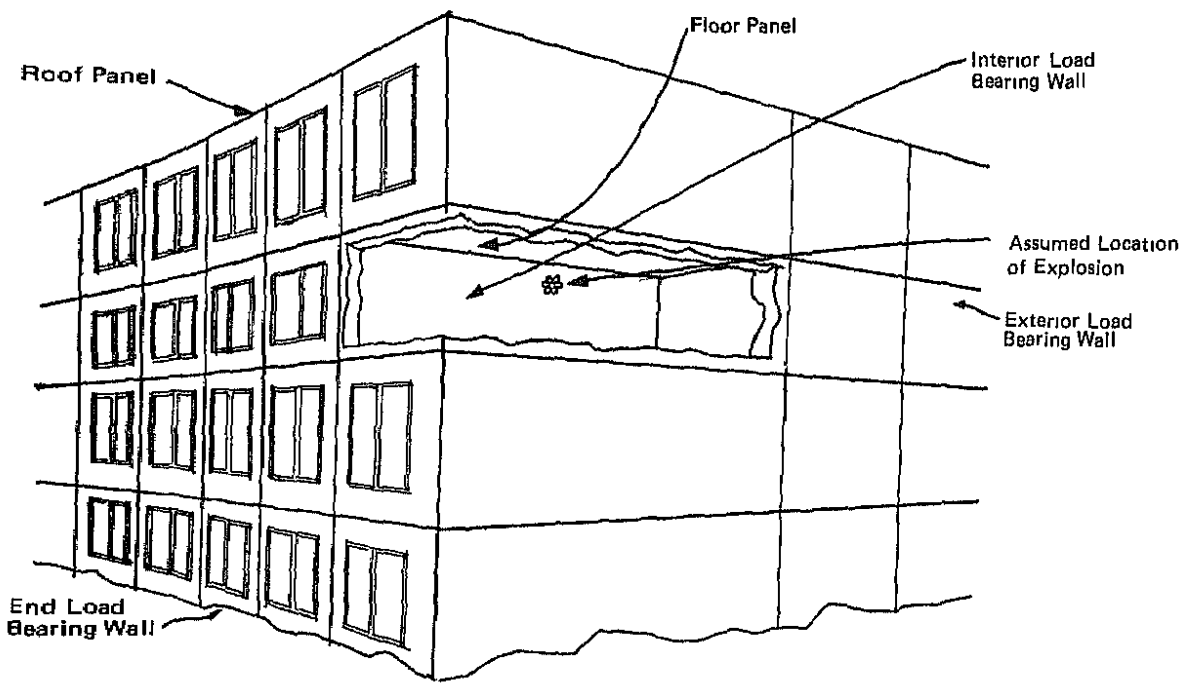


FIGURE 2.17f
BUILDING SYSTEMS INTERNATIONAL—CORNER PANELS REMOVED BY ABNORMAL LOADING

3.

EXTERIOR ENCLOSURE

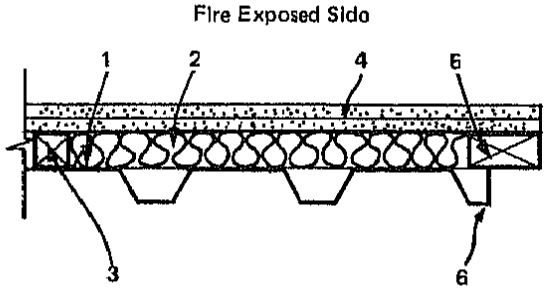
3.1 SUMMARY RESULTS OF FIRE TESTS

During Phase 1 of Operation BREAKTHROUGH many non-standard building assemblies were fire tested to determine compliance with the fire resistance criteria. The results of these tests are shown here.

The tests were conducted in accordance with ASTM Standard E119-71 except where noted. Applied loads were representative of the designs. The test results are valid for components of similar construction loaded at or below the stress levels developed by this loading. The summarized test data is presented for guidance only. The test reports should be reviewed for specific assembly details.

Generally, it was found that adhesive bonded joints without mechanical fastening were not satisfactory for use in fire rated assemblies. This factor should be considered when using adhesive bonded components.

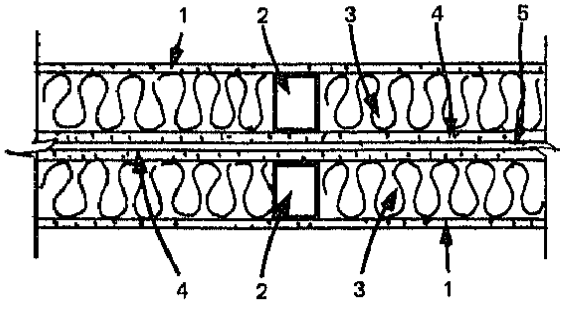
WALL ASSEMBLIES



46 Minutes EXTERIOR WALL
CONSTRUCTION:
1. .026 inch corrugated aluminum sheet glued to wood members with construction adhesive. End closure attached to 2x4 wood door jamb members and panel edge pieces with 1½ inch sheet metal screws at 12 inches o.c.
2. Compressed 2½ inch glass fiber batt
3. 2x2 furring strip, 24 inches o.c.
4. Two layers 5/8 inch Type X gypsum board staggered. Individually fastened to wood strips with No. 10 self-threading nails at 10 inches o.c.
6. 2x4 wood door jamb and panel edge pieces
6. Aluminum spline and closure

NOTES:
A. Construction contained sliding glass door opening which was covered by three layers of 6/8 inch Type X gypsum board
B. Superimposed load of 630 plf
C. Wall height 8ft., ½ inch
O. No hose stream test
E. First mode of failure: flame through occurred at 64 minutes

REF: Son, B.C., Fire Endurance Test of Corrugated Aluminum Sheet and Gypsum Board Exterior Wall Assembly, NBS Report 1041B, National Bureau of Standards, Washington, D.C. (NTIS Accession No. PB-217 366)



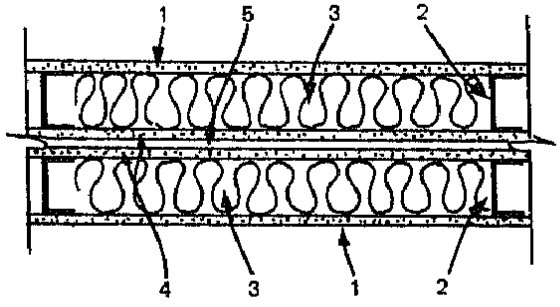
1-1/2 Hours PARTY WALL ASSEMBLY
CONSTRUCTION:
1. 6/8 inch Type X Gypsum Board fastened to steel studs with 1 inch S-12 Bugle Head screws at 12 inches o.c. in the field and 8 inches o.c. on the perimeter
2. 2 inch x 3 inch x .066 inch tubular steel studs at 24 inches o.c.
3. 3-½ inch thick glass fiber batts
4. ½ inch Type X gypsum board fastened as in No. 1.
5. ½ inch air space

NOTES:
A. Superimposed independent load of 1028 plf per wall leaf
B. Wall height 8 ft.
C. No hose stream test
D. First mode of failure: flame through of unexposed wall leaf occurred at 97 minutes, exposed wall failed by inability to sustain load at 67 minutes.

REF: Son, B.C. and Shoub, H., Fire Endurance Tests of Double Module Walls of Gypsum Board and Steel Studs, NBSIR 73-173, National Bureau of Standards, Washington, D.C. (Available through NTIS)

WALL ASSEMBLIES (con't)

Fire Exposed Side

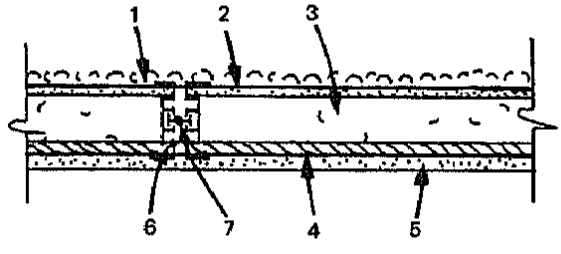


2 Hours PARTY WALL ASSEMBLY
CONSTRUCTION:
1. 5/8 inch Type X Gypsum Board applied vertically. Attached with 1 inch Type S-12 drywall screws spaced 8 inches o.c. at joints and 8 inches to 10 inches o.c at intermediate studs
2. 3 inch x 1-¾ inch 18 gage steel cee studs at 24 inches o.c.
3. 3½ inch friction fit glass fiber batts
4. ½ inch Type X gypsum board-Applied vertically with Type S-12 drywall screws spaced 8 inches o.c.
5. ¾ inch air space

NOTES:
A; Wall height 8 ft. and the exposed area 80 sq. ft.
B. Superimposed independent load of 680 plf per wall leaf
C. No hose stream test
D. First mode of failure: inability of exposed wall to sustain load at 128 minutes.

REF: National Gypsum Company, Fire Test WP-254 (Unpublished)

Fire Exposed Side

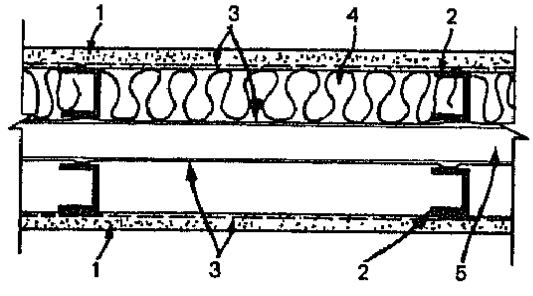


20 Minutes EXTERIOR WALL
CONSTRUCTION:
1. Epoxy matrix and stone aggregate
2. 1/8 inch cement asbestos board
3. Rigid polyurethane foam - foamed in-place
4. 5/16 inch C-D interior plywood
5. S/8 inch Type X gypsum board located to cover foam panel joints attached to plywood with 1-1/8 inch Type S bugle head screws. Fasteners spaced horizontally 4 inches o.c. and vertically 12 inches o.c.
6. Aluminum extrusion which wrapped around each 4 x 8 ft. panel
7. Aluminum spline used to hold panels together

NOTES:
A. Superimposed load of 310 plf
B. No hose stream test
C. First mode of failure: inability to sustain load at 23 min., 30 sec.

REF: Son, B.C., Fire Endurance Test of an Exterior Sandwich Panel Wall Assembly, NBS Report 10 418, National Bureau of Standards, Washington D.C. (NTIS Accession No. PB-217 363)

Fire Exposed Side



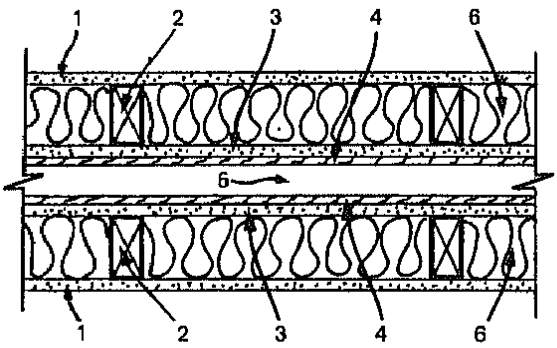
2 Hours PARTY WALL ASSEMBLY
CONSTRUCTION:
1. Cast plaster—1-1/8 inch attached through shear kays in studs
2. Galvanized 2-1/2 inch x 1-S/8 inch 18 gage steel stud at 24 inches o.c.
3. Steel strap 1 inch x .048 inch (1-1/4 ounce galvanized) front and rear each panel spot welded to studs at third points
4. 2-1/4 inch thick glass fiber batts
5. 2 inch air space

NOTES:
A. Wall height 8 ft. and the exposed area was 80 sq. ft.
B. Each wall leaf was subjected to an independently applied load of 1292 pounds per stud
C. First mode of failure: inability of unexposed wall leaf to sustain load at 2 hours, 29 minutes

REF: Ohio State University, Building Research Laboratory, Fire Test File 5048, January, 1973 (Unpublished)

WALL ASSEMBLIES (con't)

Fire Exposed Side

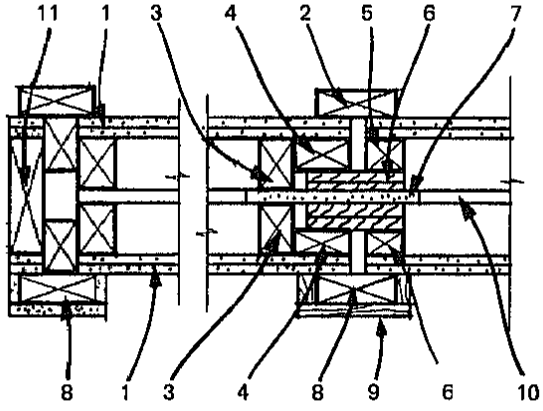


REF: National Gypsum Company, Fire Test WP-245 (Unpublished)

1-½ Hours — PARTY WALL ASSEMBLY

CONSTRUCTION:
1. ½ inch Type X foilback gypsum board
2. 2 x 4 wood studs 16 inches o.c.
3. ½ inch Type X gypsum board
4. 3/8 inch plywood sheathing
5. 2 inch air space
6. Batt insulation
7. Gypsum board and plywood nailed to 2 x 4 studs

NOTES:
A. Wall height 8 ft. and the exposed area 80 sq. ft.
B. Superimposed independent load of 740 plf per wall leaf
C. No hose stream test
D. Test terminated before failure of unexposed wall leaf. Exposed wall leaf failed by inability to sustain load at 62 minutes



Fire Exposed Side

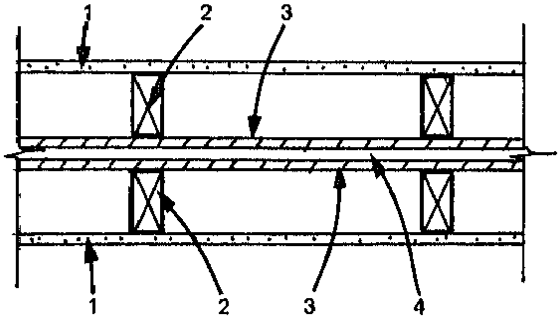
2 Hours — NON-LOAD BEARING PARTY WALL ASSEMBLY

CONSTRUCTION:
1. Two layers ½ inch Type X gypsum board. Base layer applied with 1-½ inch ring-shank nails at 12 inches o.c. Face layer glued to base layer with construction adhesive and secured with 7d cement coated box nails at 24 inches o.c. Joints of layers staggered
2. 2 x 4 joint cover
3. 2 x 3 studs at 16 inches o.c.
4. 2 x 3 stud
5. 2 x 2 filler
6. Two layers ½ inch plywood
7. ½ inch Type X gypsum board strips attached with 1-½ inch ring shank nails at 12 inches o.c.
8. 2 x 4 joint cover
9. Wood trim at one panel joint and ½ inch regular gypsum board at the other
10. ½ inch air space
11. 2 x 6 jamb

NOTES:
A. Wall height 8 ft.
B. No hose stream test
C. First mode of failure: excessive temperature rise of the unexposed wall leaf at 2 hours, 19 minutes, failure of exposed wall leaf occurred at 1 hour, 17 minutes by flame through

REF: Son, S.C., Fire Endurance Test of a Wood Stud Interdwelling Double Wall Construction, NBSIR 73-169, National Bureau of Standards, Washington, D.C. (NTIS Accession No. PB-221 184)

Fire Exposed Side



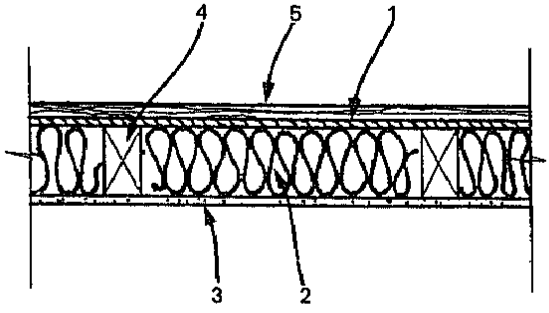
1 Hour — DOUBLE WALL ASSEMBLY

CONSTRUCTION:
1. 5/8 inch Type X gypsum board attached by gluing and nailing. Glued with 3/16 inch bead to all perimeter and intermediate members using construction adhesive. Nail with 4d ring shank nails 16 inches o.c., 3/8 inch from edges
2. 2 x 4 wood stud at 16 inches o.c.
3. ½ inch plywood attached to framing by nailing and gluing. A 3/16 inch bead of glue at intersection of panel and a 1/4 inch bead at centerline of studs. Nail at 6 inches o.c. around perimeter of panel and 12 inches o.c. to intermediate studs using 8d wire shank nails
4. ½ inch air space

NOTES:
A. Superimposed independent load of 600 plf per wall leaf
B. Wall height 8 ft.
C. No hose stream test
D. First mode of failure: excessive temperature rise of the unexposed wall leaf at 76 minutes. Exposed wall leaf failed by excessive temperature rise at 46 minutes

REF: Williamson, R.B., Saron, F.M., and Conklin, J.H., Fire Tests of Structural Double Walls, Structural Research Laboratory Report No. 72-4, University of California, Berkeley, California, January, 1972 (Unpublished)

WALL ASSEMBLIES (con't)



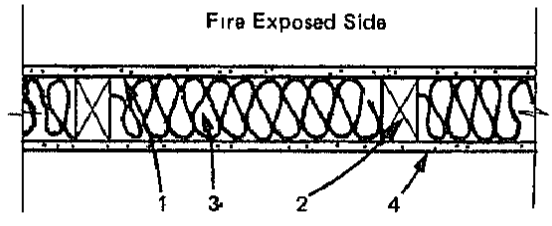
Fire Exposed Side

45 Minutes — EXTERIOR BEARING WALL

CONSTRUCTION:
1. 3/8 inch texture 1-11 exterior siding attached to studs with 8d common nails 6 inches o.c. perimeter and 12 inches o.c. at intermediate members
2. 3-½ inch batt insulation stapled to studs
3. 5/8 inch Type X gypsum board attached with adhesive and 4d S499 DX nails at 6 inches o.c. along edges and intermediate members
4. 2 x 4 studs 16 inches o.c.
5. 3/4 inch x 2 inch battens at 16 inches o.c. nailed at 16 inches o.c.

NOTES:
A. Superimposed load of 800 plf
B. Wall height 8 ft.
C. 2 x 4 fire blocking provided at midheight
D. First mode of failure: excessive temperature rise at 57 minutes, 60 minutes exceeded for other E119 conditions of acceptance

REF: Baron, F.M., and Williamson, R.D., Standard Fire Test of a Wood Stud Exterior Bearing Wall, Structural Research Laboratory Report No. 72-9, University of California, Berkeley, California, July, 1972 (NTIS Accession No. PB-212 703)

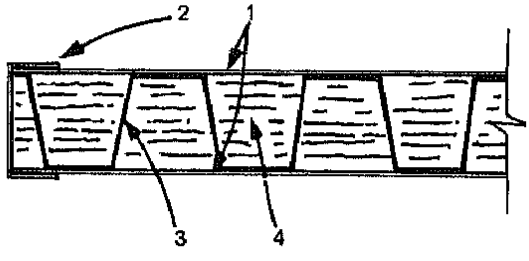


1 Hour — INTERIOR BEARING WALL ASSEMBLY

CONSTRUCTION:
1. 6/8 inch Type X gypsum board
2. 2 x 4 studs 16 inches o.c.
3. 3-½ inch insulation stapled to studs
4. ½ inch regular gypsum board
5. Gypsum board glued and nailed to studs with 4d ring shank nails at 16 inches o.c.

NOTES:
A. Superimposed load of 626 plf
B. Wall height 8 ft., 0-3/8 inch
C. 2 x 4 fire blocking provided at midheight of wall
D. Test was terminated before failure occurred

REF: Williamson, R.B., Mino, O., and Dwelle, J.C., Standard Fire Test of Wood Stud One-Hour Bearing Wall Assembly, Structural Research Laboratory Report No. 72-11, University of California, Berkeley, California, September, 1972 (NTIS Acqession No. PB-212 808)



Fire Exposed Side

20 Minutes — EXTERIOR WALL

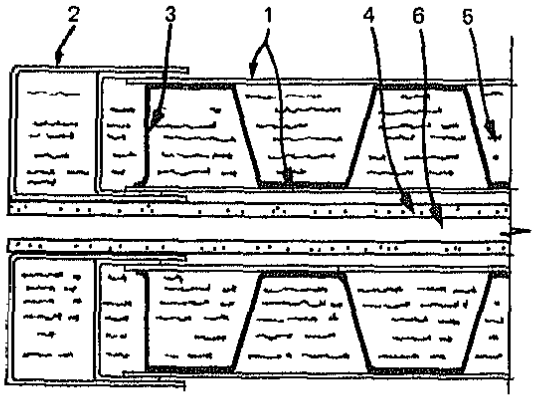
CONSTRUCTION:
1. 0.08 inch structural composite FRP sheet
2. Molded end cap
3. 0.05 inch structural composite FRP stiffener
4. Rock wool insulation, density-14.3 lbs./ft.^{3}, sodium silicate and water binder
6. 2 x 4 wood header and bottom plate
6. Composite FRP bonded with proprietary adhesive

NOTES:
A. Superimposed load of 700 plf
B. Wall height 8 ft.
C. No hose stream test
D. Rating established for failure to sustain load at 28 minutes, thermal failure occurred at 19 minutes

REF: Williamson, R.B. and Brauer, B.B., Fire Test of Structural Wall Panel, Structural Research Laboratory Report No. 73-1, University of California, Berkeley, California, January, 1973 (Unpublished)

3.1 SUMMARY RESULTS OF FIRE RESULTS
continued

WALL ASSEMBLIES (cont')



Fire Exposed Side

1-½ Hours PARTY WALL ASSEMBLY

CONSTRUCTION:

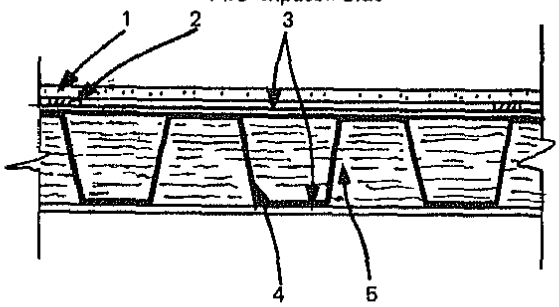
1. 0.08 inch structural composite sheet
2. Molded end cap
3. 0.06 inch structural composite stiffener coated with intumescent paint and bonded to face sheets with proprietary adhesive
4. 6/8 inch Type X gypsum boerd glued and nailed (6d at 6 inches o.c.) to top and bottom wood plates. Joints in opposite layers staggered 24 inches o.c., 3/16 inch asbestos millboard furring strips at top and bottom
5. Rock wool insulation, sodium silicate and water binder
6. 1 inch air space

NOTES:

A. Superimposed independent load at 700 plf per wall leaf
B. Wall height 8 ft.
C. No hose stream test
D. First mode of failure: excessive temperature rise occurred at 99 minutes on unexposed wall leaf, flame through of same wall leaf occurred at 104 minutes

REF: Williamson, R.B. and Baron, F.M., Fire Test of Structural Party Wall, Structural Research Laboratory Report 71-11, University of California, Berkeley, California, November, 1971 (Unpublished)

Fire Exposed Side



1 Hour LOAD BEARING WALL

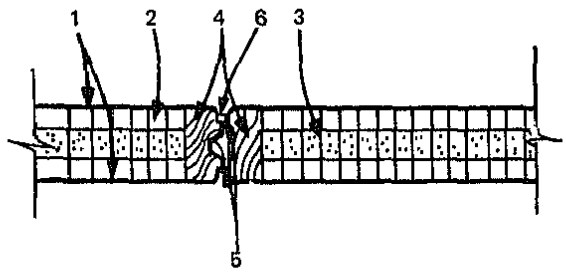
CONSTRUCTION:

1. 5/8 inch Type X gypsum boerd, 1 inch No. 10 sheet metal screws at 12 inches o.c. at each furring strip. Glued and nailed (6d at 6 inches o.c.) to top and bottom wood plates
2. 3/16 inch asbestos millboard furring strips at 24 inches o.c.
3. 0.08 inch structural composite FRP sheet
4. 0.05 inch structural composite FRP stiffener
5. Rock wool insulation,sodium silicate and water binder

NOTES:

A. Superimposed load of 700 plf
B. Wall height 8 ft.
C. Test was terminated before failure occurred

REF: Williamson, R.B., Brauer, B.B. and Baron, F.M., Fire Test of Structural One-Hour Firewall, Structural Research Laboratory Report 72-7, University of California, Berkeley, California, June, 1972 (Unpublished)



Fire Exposed Side

20 Minutes EXTERIOR WALL

CONSTRUCTION:

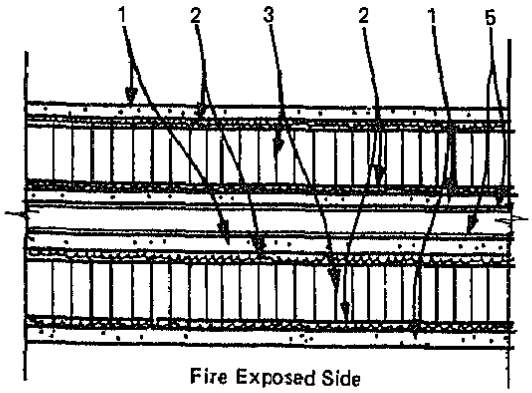
1. 26 gaga steel facing
2. 3 inch thick peper honeycomb core bonded to steel facing with epoxy adhesive
3. 1-½ inch polyurethene foam insulation
4. 3 inch nominal mill edge wood blocks
5. Butyl sealant
6. Vinyl Tape

NOTES:

A. Superimposed load of 237 plf
B. Wall height 8 ft.
C. No hose stream test
D. 18 foot wide panel wall assembly constructed of four, 4 foot wall panels
E. First mode of failure: excessive temperature rise at 8 minutes, inability to sustain load occurred at 23 minutes

REF: Son, B.C., Fire Endurance Tests of Exterior Wall and Roof/Ceiling Constructions for Single Family House, NBSIR 73-135, National Bureau of Standards, Washington, D.C., January, 1972 (NTIS Accession No. PB 221 310)

WALL ASSEMBLIES (con't)



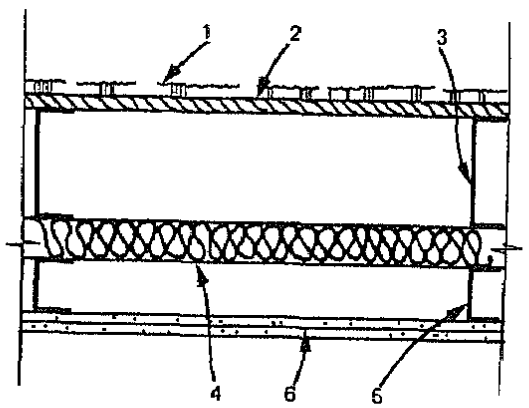
1 Hour DOUBLE WALL ASSEMBLY
CONSTRUCTION:
1. 5/8 inch Type X gypsum wallboard
2. 24 ounce woven roving glass fiber
3. 3 inch thick paper honeycomb core
4. All components were bonded with adhesive
5. Glass fiber mat

NOTES:
A. Superimposed independent load 700 plf per wall leaf
B. Wall height 8 ft. and the exposed area 80 sq. ft.
C. No hose stream test
D. First mode of failure: inability of unexposed wall to sustain load at 75 minutes

REF: National Gypsum Company, Fire Test WP-212 (Unpublished)

FLOOR/CEILING ASSEMBLIES

Fire Exposed Side

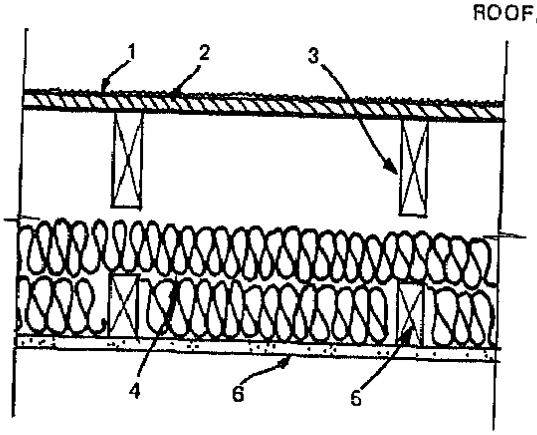


1 Hour
CONSTRUCTION:
1. Carpet and cushion/vinyl flooring
2. 3/4 inch Douglas Fir plywood subflooring applied per pendicular to the joists with drywall screws spaced 12 o.c.
3. 6 inch x 1 3/4 inch 18 gage steel floor joists at 24 inch
4. 2 inch glass fiber blanket laid over ceiling joists
5. 3 inch x 1-3/4 inch 18 gage steel ceiling joist at 24 inc
6. Two layers ½ inch Type X gypsum board. First layer applied perpendicular to joists and attached with 1 in Type S-12 drywall screws at 12 inches o.c. Second lay applied with long dimension parallel to joists and attached with 1-5/8 inch Type S-12 drywall screws at 12 inches o.c.

NOTES:
A. Half of test floor covered with carpet and pad-other ha vinyl flooring and adhesive
B. Superimposed load of 40 psf on span of 11 feet, 8 inch
C. First mode of failure: inability to sustain load occurre at 71 minutes

REF: National Gypsum Company, Fire Test FC-167, Floor Ceiling Assembly, January, 1972 (Unpublished)

ROOF/CEILING ASSEMBLIES



Fire Exposed Side

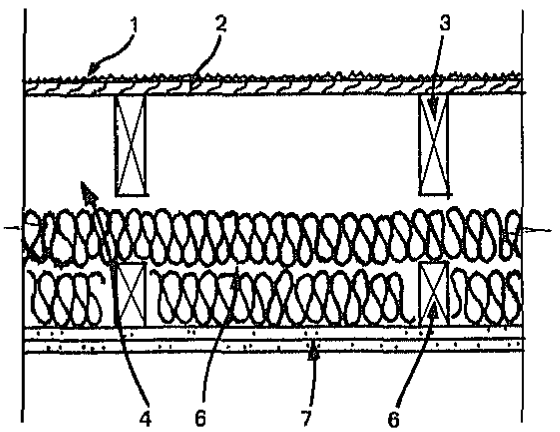
46 Minutes
CONSTRUCTION:
1. Vinyl roofing meterial adhesively attached to plywood
2. ½ inch plywood sheathing attached with long dimensio parallel to joists. Attached with 1/4 inch bead of adhesi and nailed with 6d nails spaced 8 inches o.c. at the joint and 12 inches o.c. at the intermediate joists
3. 2 x 6 roof joists 16 inches o.c.
4. 2 layers of 3-½ inch glass fiber batt insulation
5. 2 x 4 ceiling joists 18 inches o.c.
6. ½ inch Type X gypsum board applied parallel to joists. A 1/4 inch bead of adhesive applied to each joist prior to nailing with No. 4 ring shank nails at 8 inches o.c. around the perimeter and 12 inches o.c. on intermediate joists

NOTES:
A. Superimposed roof load of 30 psf on span of 11 ft.,11-½
B. No hose stream test
C. First mode of failure: excessive temperature rise

REF: National Gypsum Company, Fire Test RC-169 (Unpublished)

3.1 SUMMARY RESULTS OF FIRE TESTS
continued

ROOF/CEILING ASSEMBLIES (con't)

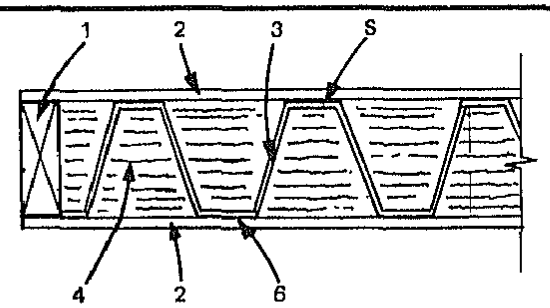


Fire Exposed Side

1 Hour ROOF/CEILING ASSEMBLY
CONSTRUCTION
1. Vinyl roofing material adhesively attached to plywood
2. ½ inch plywood sheathing with long dimension parallel to joists. Attached with ¼ inch bead of adhesive and nailed with 6d nails spaced 6 inches o.c. at the joints and 12 inches o.c. at the intermediate joists.
3. 2 x 6 roof joists at 16 inches o.c.
4. Air space
5. Two layers 3-½ inch glass fiber batt insulation
6. 2 x 4 ceiling joists at 16 inches o.c.
7. ½ inch Type X gypsum—two layers. First layer applied parallel to joists with ¼ inch bead of adhesive at each joist and with No. 4 ring shank nails at 6 inches o.c. around the perimeter and 12 inches o.c. on intermediate joists. Second layer parallel to joists with joints offset 16 inches and attached with 7d cement coated nails spaced 16 inches o.c. at the joints. 1-¼inch Type "G" drywall screws were placed 2 inches back from the joint and driven into the first layer at 12 inches o.c. on either side of the joint

NOTES:
A. Superimposed roof load of 30 psf on span of 11 feet, 1-½ inches
B. No hose stream test
C. First mode of failure: flame through at 84 minutes

REF: National Gypsum Company, Fire Test RC-171 (Unpublished)

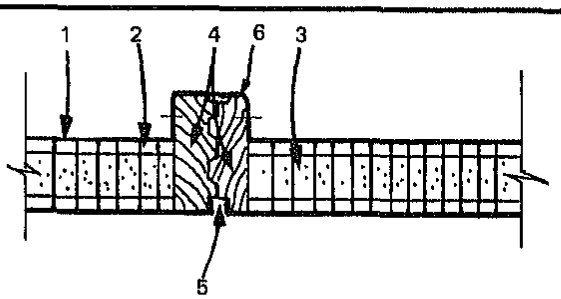


Fire Exposed Side

46 Minutes ROOF/CEILING PANEL
CONSTRUCTION:
1. 2 x 6 rim joists at edge of test specimen
2. 0.161 inch structural composite FRP sheet
3. 0.06 inch structural composite FRP stiffener coated with proprietary intumescent paint, both sides
4. Cavities filled with rock wool insulation
6. Bonded with proprietary adhesive

NOTES:
A. Superimposed concentrated loads developing bending moment equivalent to that developed by uniform load of 20 psf on span of 11 feet, 4-½ inches
B. No hose stream test
C. First mode of failure: inability to sustain load occurred at 48 minutes

REF: Ohio State University, Standard ASTM Fire Endurance Test on a Roof and Ceiling Assembly, Building Research Laboratory Report No. 5087, Columbus, Ohio, September, 1971 (Unpublished)



Fire Exposed Side

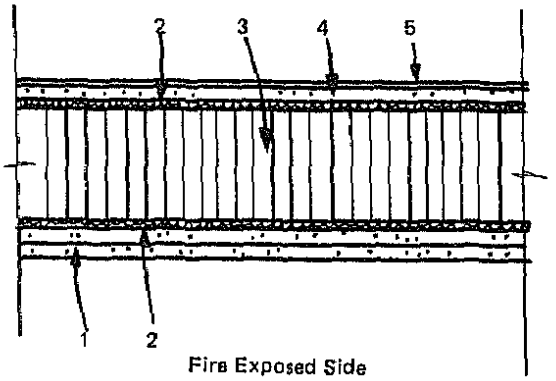
10 Minutes ROOF/CEILING ASSEMBLY
CONSTRUCTION:
1. 26 gage steel facing each side
2. 3 inch thick peper honeycomb core
3. 2-1/4 inch polyurethane foam insulation
4. 6 inch mill edge wood blocks
6. Butyl tape
6. 26 gage galvanized steel roof cap attached with 4d nails

NOTES:
A. Superimposed load of 28.6 psf on space of 13 feet, 5 inches
B. No hose stream test
C. First mode of failure: excessive temperature rise at 10 minutes, inability to sustain load occurred at 17 minutes

REF: Son, B.C., Fire Endurance Tests of Exterior Wall and Roof/Ceiling Construction for Single Family House, NBSIR 73-136, National Bureau of Standards, Washington, D.C., January, 1972 (NTIS Accession No. PB 221 310)

3.1 SUMMARY RESULTS OF FIRE TESTS
continued

ROOF/CEILING ASSEMBLIES (con't)

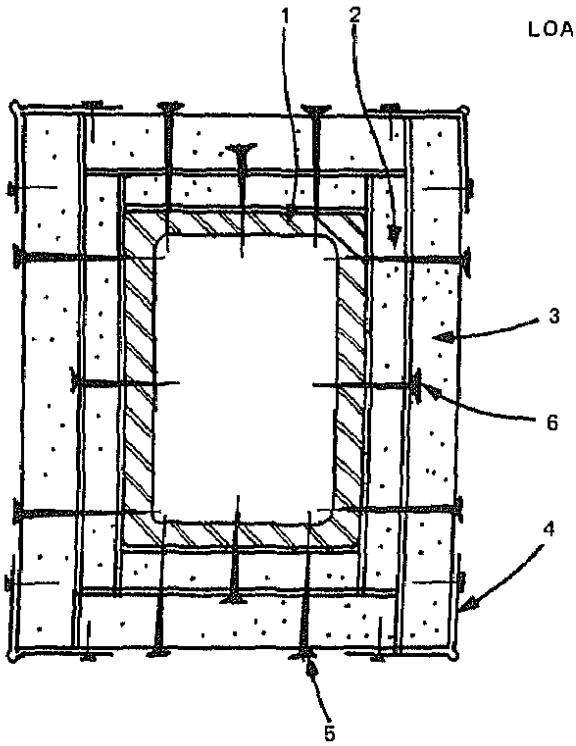


1 Hour ROOF/CEILING TEST
CONSTRUCTION:
1. Two layers of 5/8 inch Type X gypsum board
2. 24 ounce woven roven glass fiber mat
3. 6 inch thick paper honeycomb core
4. Single layer 6/8 inch Type X gypsum board
5. Continuous strand fiber mat
6. All components were bonded with adhesive. In addition, the exposed layer of wallboard was attached to the second layer with 1-½ inch long 7/16 inch crown staples spaced 24 inches o.c. along each edge and down center of each board and 12 inches o.c. at end joints

NOTES:
A. Superimposed load of 18.6 psf
B. No hose stream test
C. First mode of failure: flame through occurred at 66 minutes

REF: National Gypsum Company, Fire Test FC-169 (Unpublished)

LOAD SUPPORTING COLUMN

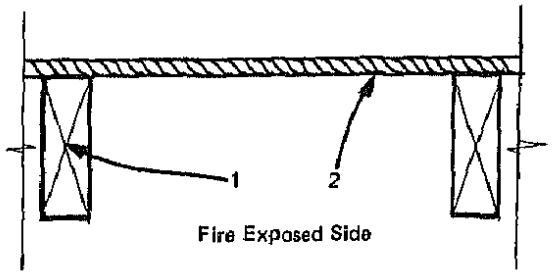


1 Hour STEEL COLUMN
CONSTRUCTION:
1. 2 inch x 3 inch x 3/16 inch hot rolled steel column
2. 3/8 inch gypsum board
3. ½ inch Type X gypsum board
4. Gypsum corner reinforcement attached with 5/18 inch drywall nails at 24 inches o.c.
5. 1-5/8 inch Type S-12 screws at 18 inches o.c.
6. 1 inch Type S-12 screws at 16 inches o.c.

NOTES:
A. Superimposed load of 7110 pounds
B. No hose stream test
C. First mode of failure: inability to sustain load at 61 minutes, 60 seconds

REF: Son, B.C., Fire Endurance Test on a Steel Tubular Column Protected With Gypsum Board, NBSIR 73-165, National Bureau of Standards, Washington, D.C. (Available Through NTIS)

EXPOSED FLOOR ASSEMBLY



10 Minutes
CONSTRUCTION:
1. 2 x 8 joists at 16 inches o.c. Steel adjustable bridging used along assembly centerline perpendicular to joists
2. 5/8 inch tongue and groove plywood attached with 8d nails spered 10 inches o.c. Joints protected with 2 x 3 inch wood blocking

NOTES:
A. Superimposed load of 21 psf on 13 feet, 6 inches span
B. No hose stream test
C. First mode of failure: excessive temperature rise at 10 minutes

F: Son, B.C., Fire Endurance Tests of Unprotected Wood-Floor Construction for Single Family Residences, National eau of Standards, Washington, O.C. (Publication in process)

3.2 MULTI-PURPOSE SHIPPING ROOF

Housing Manufacturer: Scholz

Many housing module manufacturers temporarily cover the top and sides of modules with plywood or plastic tarps during transportation and erection. Many times the plastic is torn, allowing road dust, rain, etc., to damage the module. Plywood often gets discarded at the site, thereby negating the reusable feature. Unanticipated yard or site storage of modules often causes weather damage because these protection measures are not sufficient over long periods of time.

Galvanized steel sheet is used in this housing system as a protective cover laid over the wood joist and plywood ceiling of the lower module of a two-story arrangement. In addition to providing a durable protection against weather, the layer of steel provides added fire endurance and some acoustical benefits which are important in multifamily units. Over long unanticipated storage periods this material will not break nor tear because of wind. Finally, its thinness means it can be left in place without affecting the construction detailing. Wall openings are covered with reusable plywood.

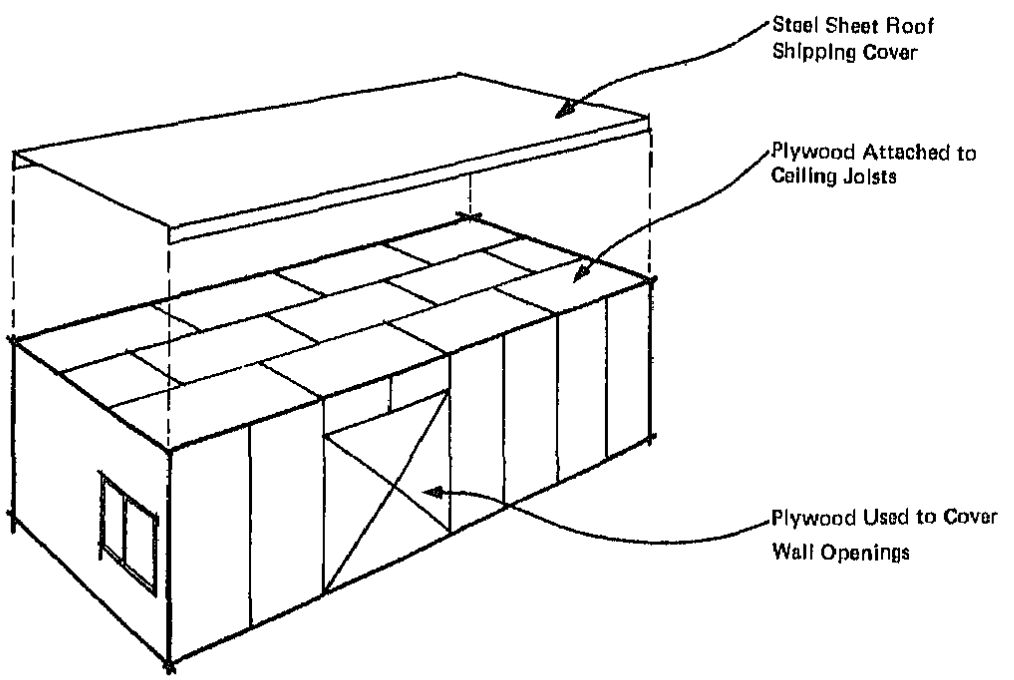


FIGURE 3.2
SHEET METAL SHIPPING ROOF ON MODULE

3.3 FIRE-RATED DOOR FOR CHASE ACCESS AND PROTECTION

Housing Manufacturer: Hercules

In multi-family, low and high-rise housing, access to chases and plenums is often provided by removable panels constructed of plywood framed into the conventional gypsum/wood stud wall construction. This lessens the fire endurance of the chase below that required by some building codes. A neat, aesthetically pleasing solution is the fire-rated steel door attached with sheet metal screws to a steel door frame.

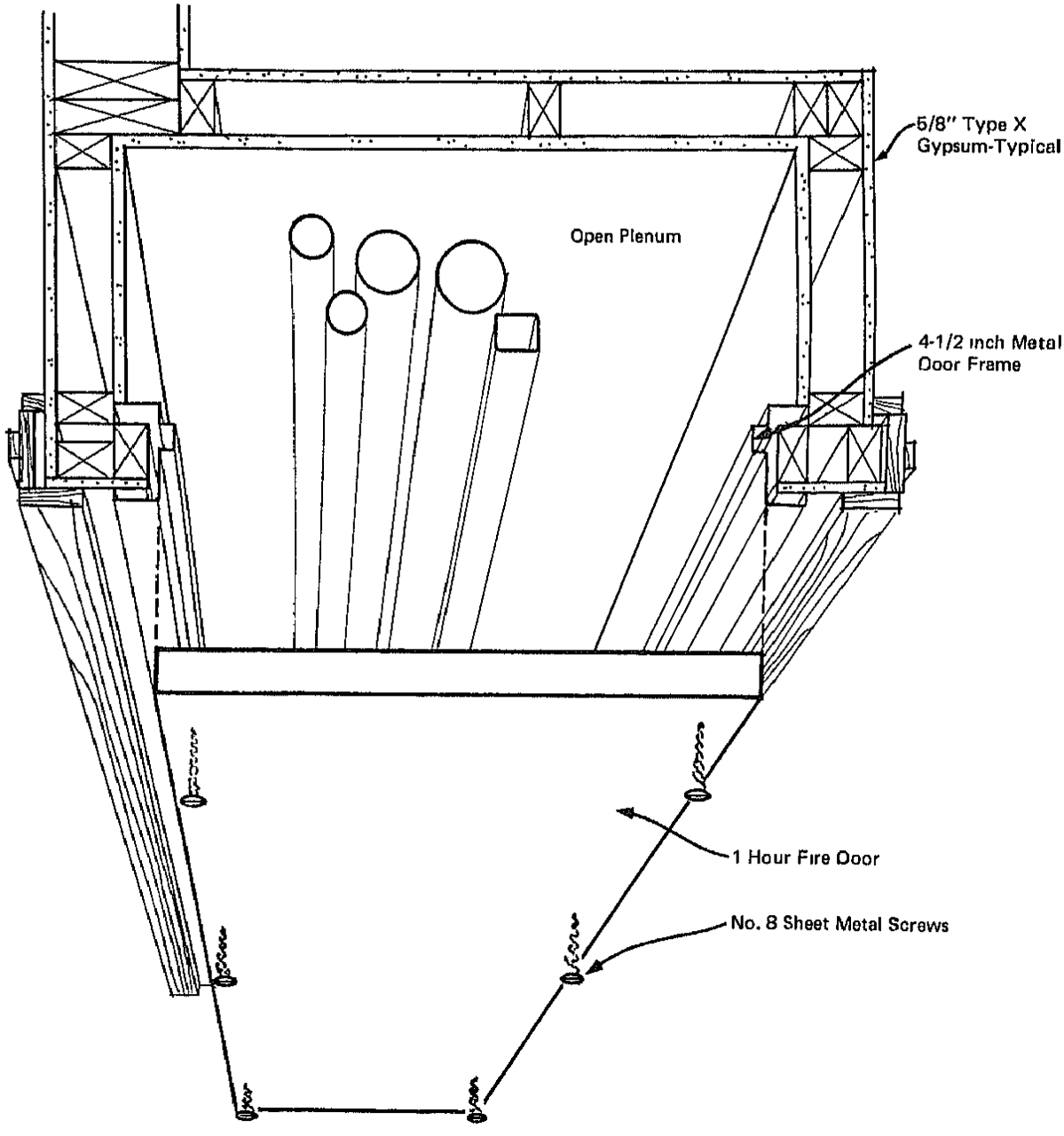


FIGURE 3.3
FIRE RATEO ACCESS DOOR FOR CHASE

3.4 FIRE RESISTANT CONTINUOUS RIDGE VENT IN MULTI-FAMILY UNITS

Housing Manufacturer: Alcoa

The use of continuous ridge vents to ventilate attic spaces in multi-family and single-family attached dwellings provides a flanking path for fire over the party wall. A solution is to pack the ridge vent with mineral wool for a distance of 12 inches minimum on each side of a party wall which permits use of a continuous ridge vent without decreasing the fire resistance of the party wall. Breaking the continuity of the ridge vent would add cost and adversely affect the appearance.

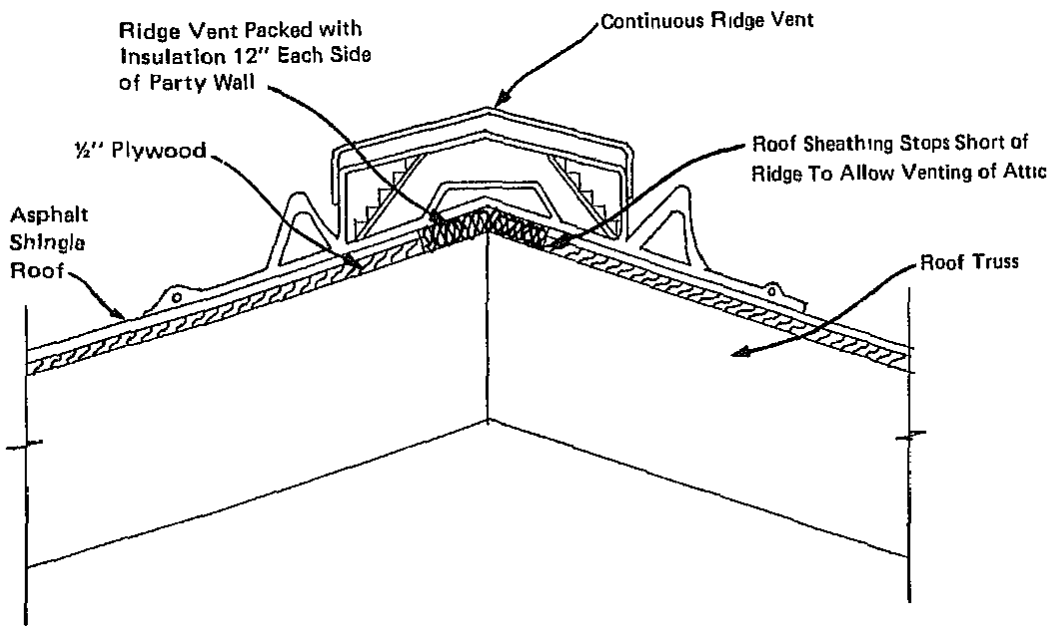


FIGURE 3.4
CONTINUOUS RIDGE VENT PACKED WITH INSULATION

3.5 ATTIC VENT LOCATION RETARDS FIRE SPREAD

Housing Manufacturer: Scholz

A fire-rated ceiling assembly may be required in townhouses or garden apartments to protect the attic spaces. It is known that a fire spreads quickly and threatens adjacent units if it should get into the attic. What generally is not recognized is that the fire could bypass the ceiling by going out the window and up through vents in the soffit.

To reduce this possibility, attic vents are located in the soffit a minimum of three feet from the projection of the vertical edge of the nearest window.

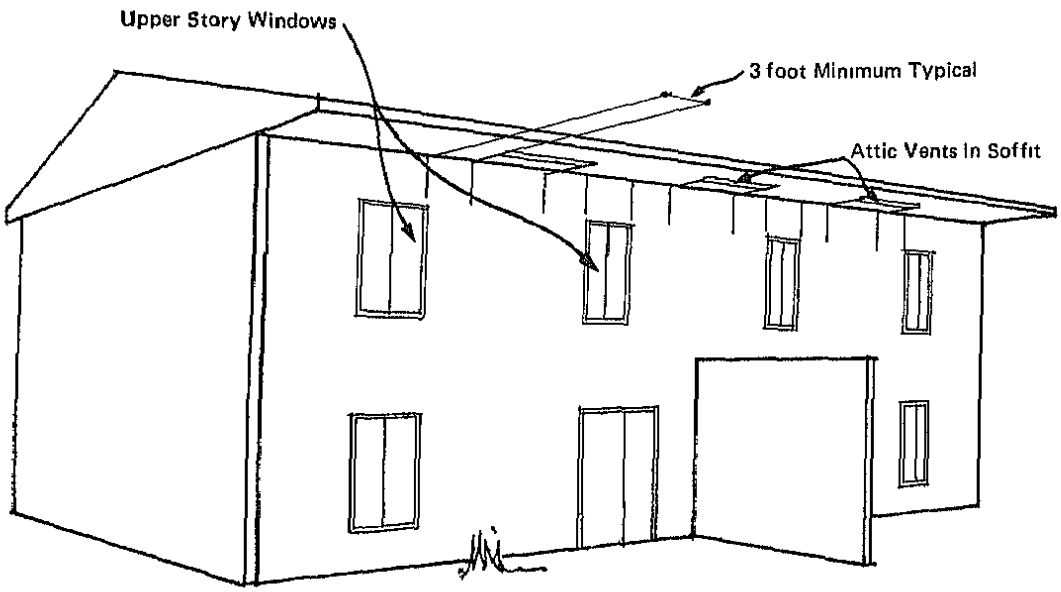


FIGURE 3.5
ATTIC SOFFIT VENT LOCATED TO SIDE OF WINDOWS

3.6 FASCIA VENT RETARDS FIRE SPREAD IN MULTI-FAMILY UNITS

Housing Manufacturer: Christiana Western

An alternate response to the potential fire spread problem discussed in 3.5 was to relocate the attic vents from the soffit (Figure 3.6a) to the fascia (Figure 3.6b).

Fire resistance of the continuous soffit was provided by a 1/2-inch layer of gypsum board backing and 3/8-inch exterior plywood.

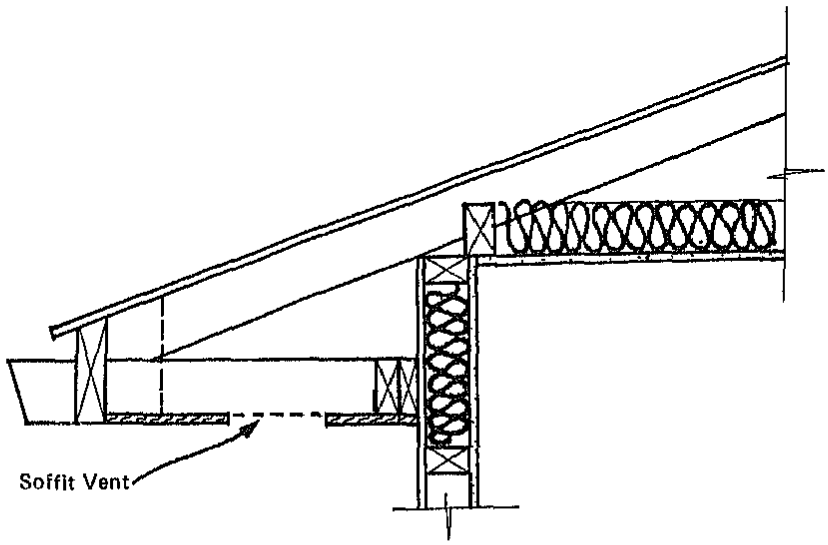


FIGURE 3.6a
ATTIC VENT LOCATED ON SOFFIT

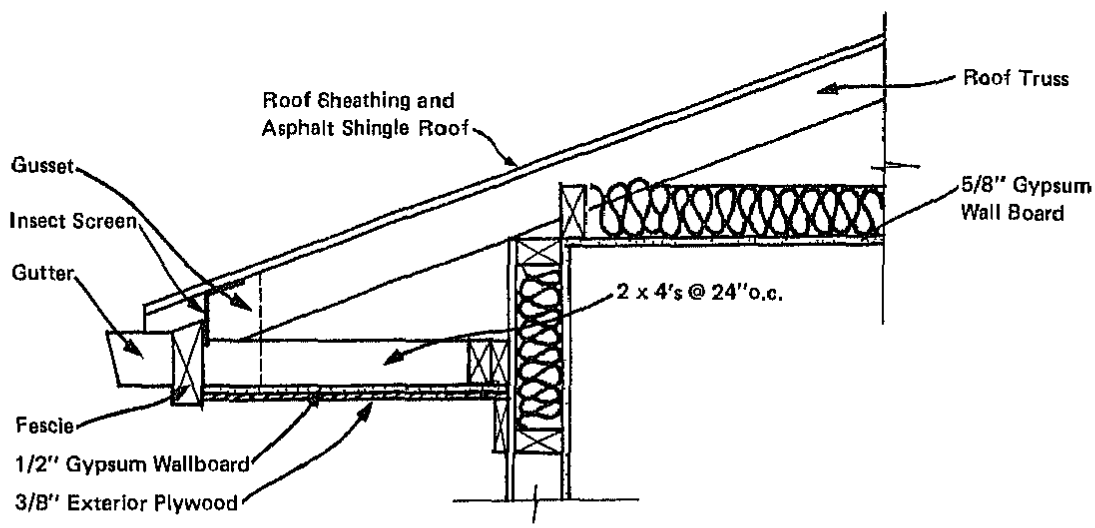


FIGURE 3.8b
ATTIC VENT RELOCATED FROM SOFFIT TO FASCIA

3.7 BERM SHIELDING AGAINST EXTERIOR NOISE

SITE: Memphis, Tennessee

An effective way to shield dwellings from roadway or factory noise is to construct an earth berm adjacent to a building. The berm ridge deflects direct sound and lowers the sound level reaching dwelling units.

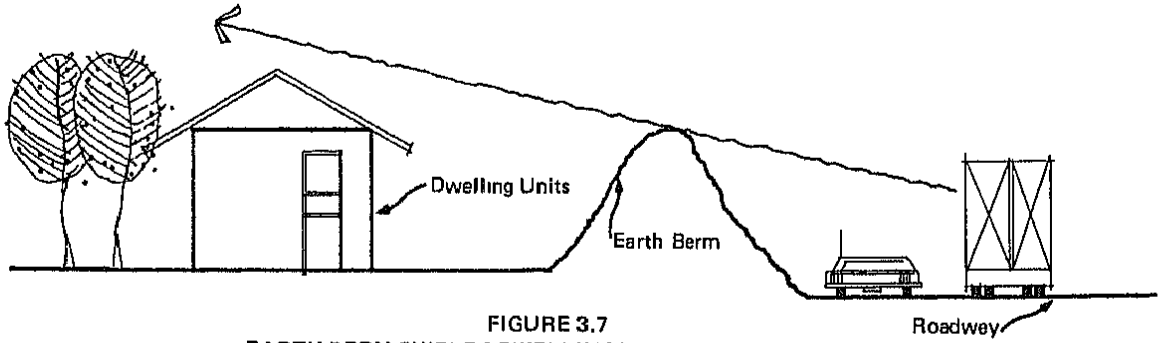


FIGURE 3.7
EARTH BERM SHIELDS DWELLINGS FROM ROAD NOISE

3.8 STEEL ROOF DECK AND MEMBRANE ROOFING

Housing Manufacturer:
Pantek

The roof construction of this housing system departs from the conventional timber roof normally used in single-family housing by using a steel roof deck. The deck is oriented with the stiffened web elements up and the flat surface down to form a finished ceiling with a board-like appearance. The roofing system consists of 1-inch thick rigid insulation board and 1/2 inch plywood sheathing screw attached to the steel deck with membrane roofing placed over the plywood. Batt insulation is placed in the pans. When necessary for fire requirements, gypsum board can be attached to the bottom metal surface.

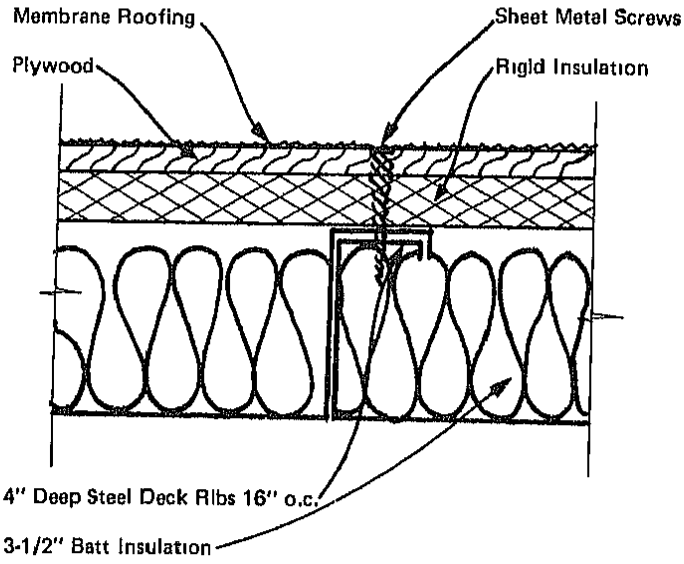


FIGURE 3.8
PANTEK ROOF DECK CROSS SECTION

3.9 ROOF PANELS NEED NO COVERING

Housing Manufacturer: Republic Steel

The roof construction for this housing system consists of 3 inch thick prefabricated paper honeycomb sandwich panels with steel skins and milled wood edge members, Figures 3.9a and b. The tongue and groove wood members are placed together and sealed against moisture penetration with sealant and a steel roof cap nailed to the edge member. No additional roof covering is required. See 2.10 and 3.13 for description of the panel configuration.

A variety of decorative fascade treatments are used to add individual style to the flat roof of the dwelling.

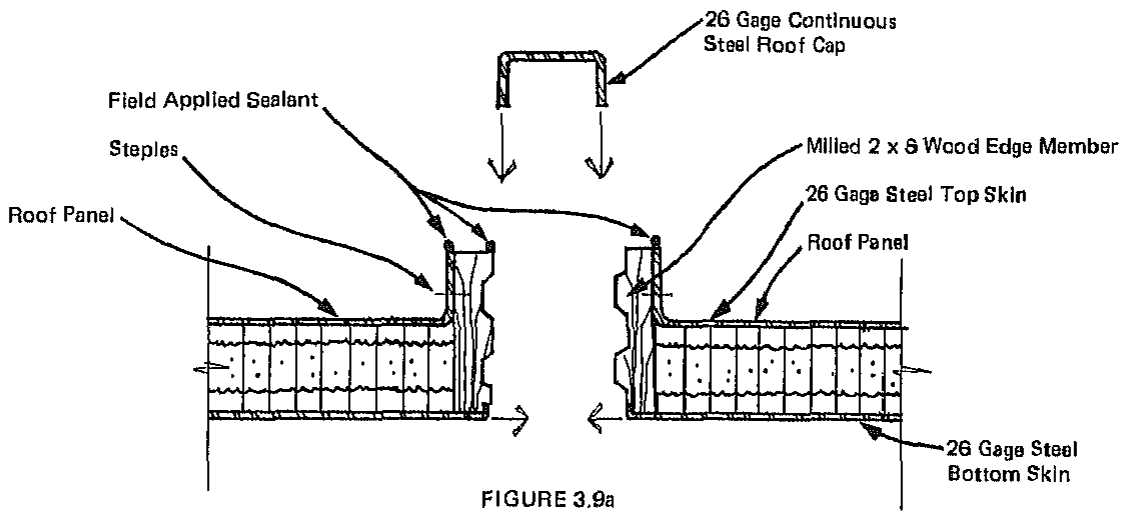


FIGURE 3.9a
ROOF PANEL ASSEMBLY SEQUENCE

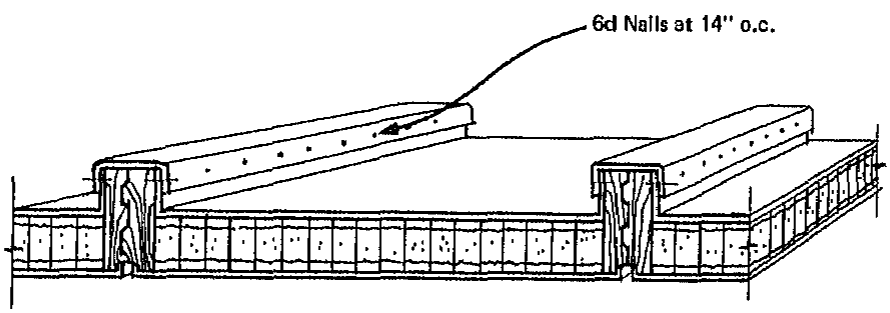


FIGURE 3.9b
ASSEMBLED ROOF PANEL

3.10 INSULATED ROOF MEMBRANE ASSEMBLY

Housing Manufacturer:
Descon/Concordia

Descon/Concordia utilizes an Insulated Roof Membrane Assembly (IRMA) which is a patented built-up roofing system using conventional materials and construction techniques. The roof membrane is applied directly to the precast concrete roof panel with styrofoam insulation on top bedded in the final layer of asphalt of the built-up roof. The insulation is then topped with a layer of crushed stone. Since the membrane is on the warm side of the insulation, it is less vulnerable to thermal cycling and is protected from ultraviolet degradation.

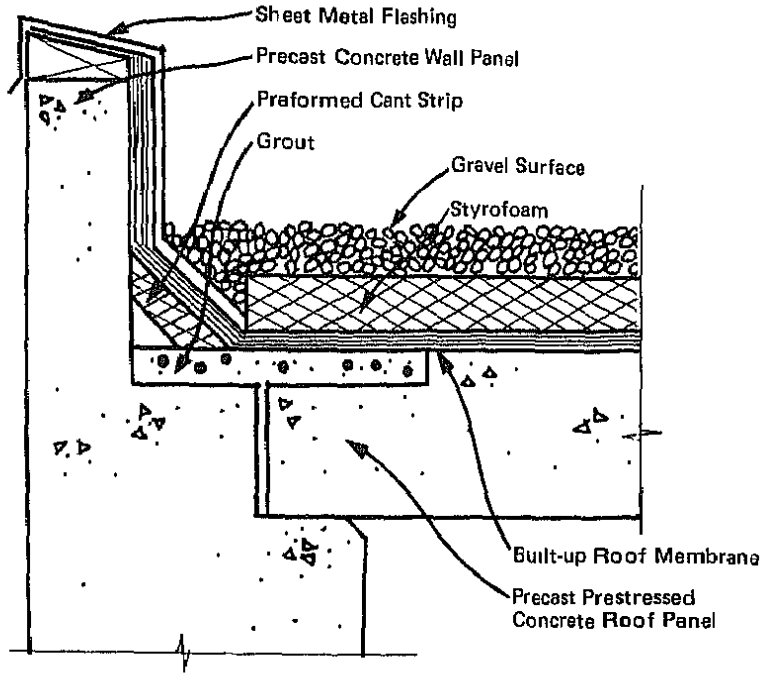


FIGURE 3.10
INSULATED ROOF MEMBRANE ASSEMBLY

3.11 INNOVATIVE PANEL–PAPER HONEYCOMB CORE WITH GLASS REINFORCED PLASTIC SKINS

Housing Manufacturer: TRW

This system uses conventional and innovative materials to factory produce wall, roof and floor panels. The wall panels are symmetrical with structural exterior skins made of woven glass fiber reinforced polyester resin bonded to gypsum board. An intermediate layer of this same material bonds the gypsum board to a phenolic-impregnated, kraft paper honeycomb core. The floor and roof panels are similar except plywood is used in lieu of gypsum board in some applications. Three inch honeycomb cores are used for wall panels and 6 inch cores are used for roof and floor panels.

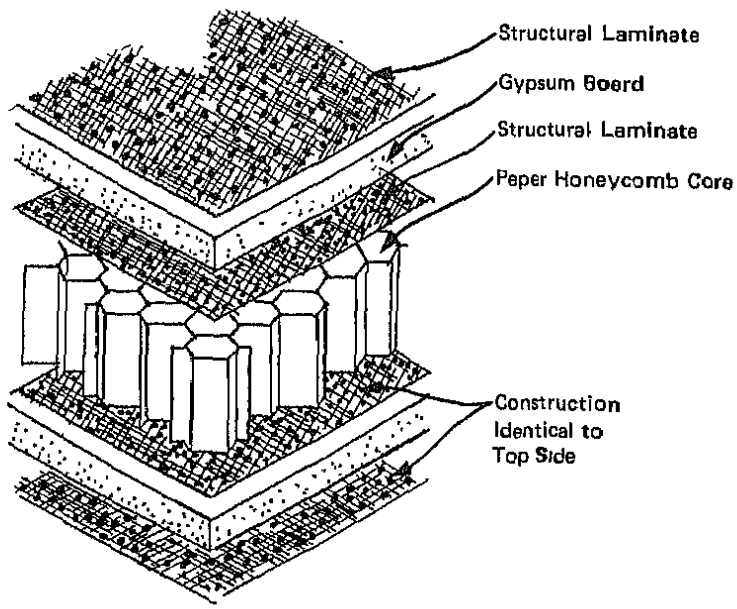


FIGURE 3.11
TYPICAL WALL PANEL CROSS SECTION

3.12 INNOVATIVE PANEL—POLYESTER COMPOSITE PANEL

Housing Manufacturer:
Material Systems

This system employs roof and wall sandwich panels constructed from laminated sheets of polyester resin reinforced with chopped strands of glass fibers. The basic panel consists of face sheet bonded to each side of a corrugated core sheet by a polyester adhesive, Figure 3.12. The nominal thickness of the face sheets is 0.08 inch and the corrugated core, 0.05 inch. Wall and roof panels contain wood surround members for field attachment purposes, Figure 2.10j. Cavities in exterior wall and roof panels are filled with mineral wool for thermal insulation and fire resistance.

Roof panels are waterproofed with either a factory-applied elastomeric coating or a field-applied built-up roofing membrane. Exterior and interior surfaces of wall panels are normally sprayed with a textured coating for architectural effect.

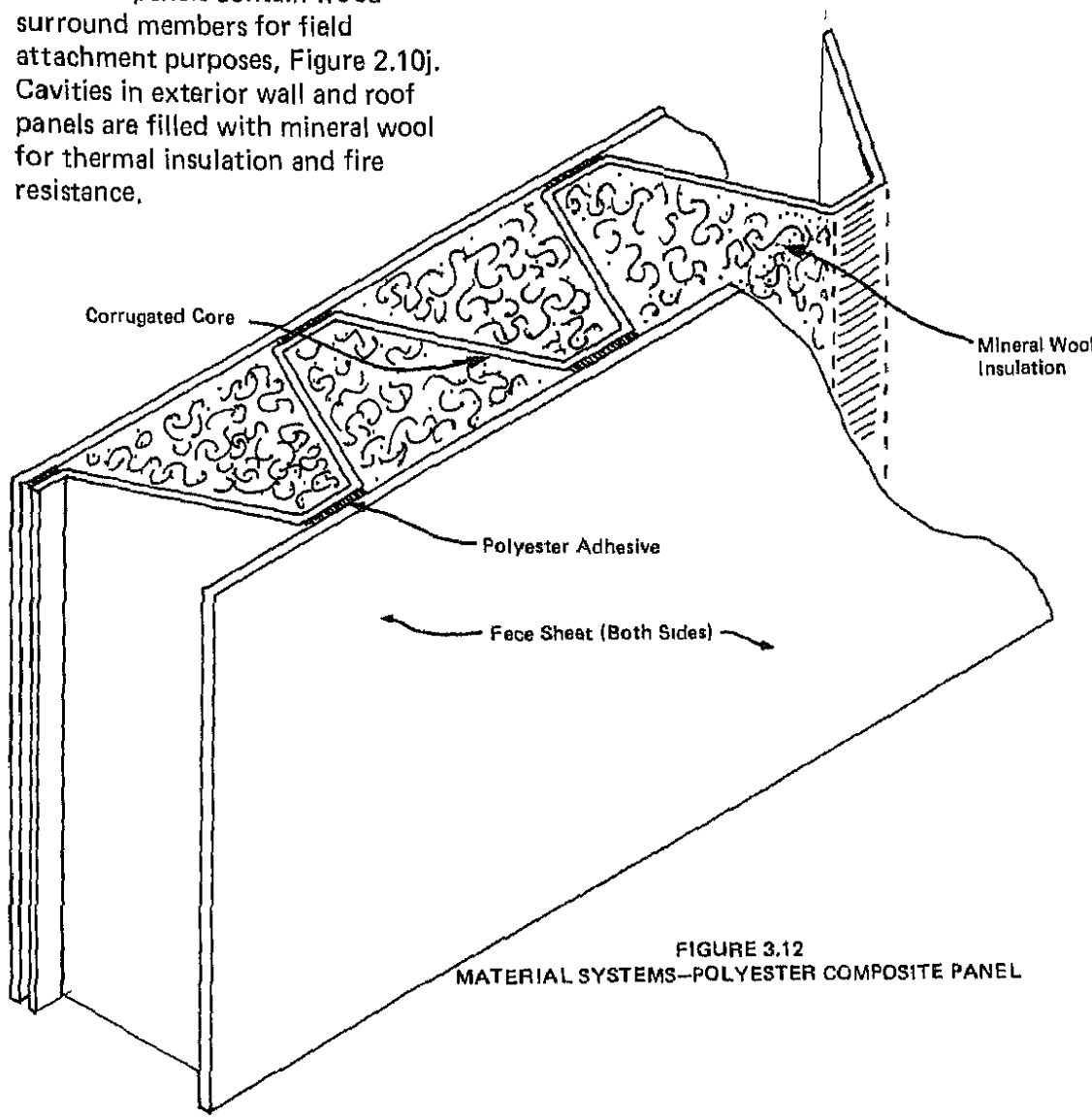


FIGURE 3.12
MATERIAL SYSTEMS—POLYESTER COMPOSITE PANEL

3.13 INNOVATIVE PANEL—PAPER HONEYCOMB CORE WITH STEEL SKINS

Housing Manufacturer:
Republic Steel

Factory produced sandwich panels are used for walls, floors, and roofs. The roof and wall panels are 3 inches thick and are constructed of 26 gage steel sheet adhesive bonded to each side of a resin-impregnated paper honeycomb core, Figure 3.13. The floor panels are similar except the upper surface is 3/8 inch plywood instead of a steel skin. Urethane foam is pressed into the honeycomb prior to final assembly to improve thermal properties. Wood edge members are fastened around the perimeter of the panels as shown in Figures 2.10a,b, and c.

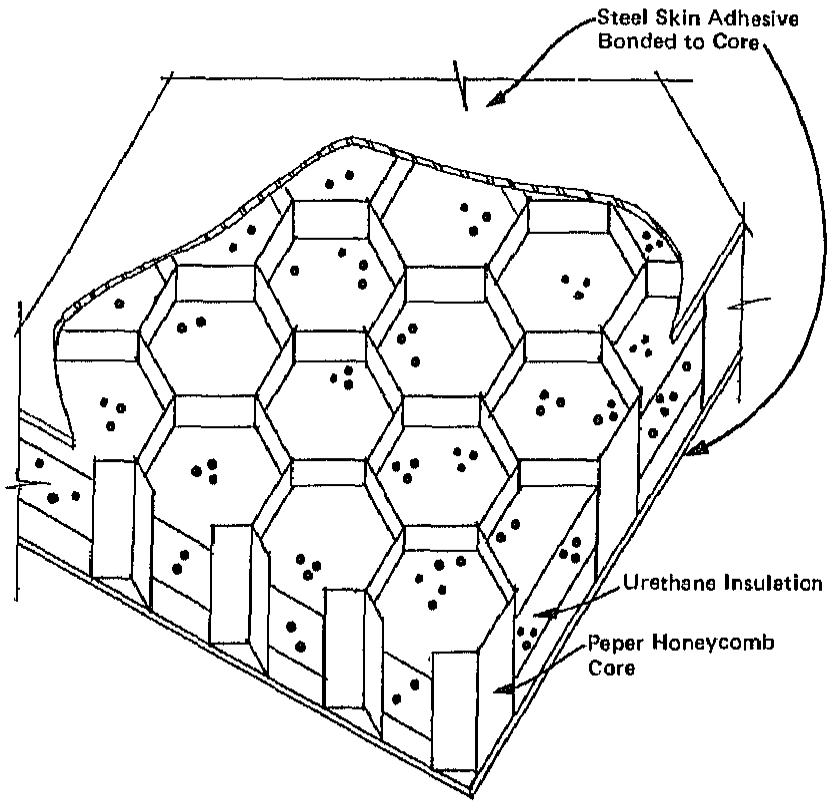


FIGURE 3.13
REPUBLIC STEEL—SANDWICH PANEL CROSS SECTION

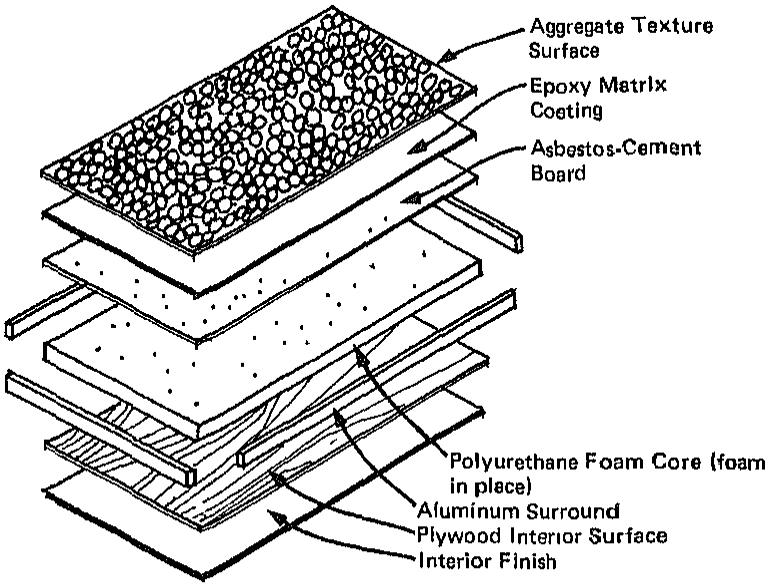


FIGURE 3.14
PANTEK—SANDWICH PANEL CONSTRUCTION OF EXTERIOR WALLS

3.14 INNOVATIVE PANEL—POLYURETHANE CORE

Housing Manufacturer: Pantek

This site erected panelized system utilizes 3-inch thick sandwich wall panels consisting of low density polyurethane foam which is foamed in place at the factory between two face sheets. Exterior wall panels have a 5/16 inch plywood covered with gypsum wallboard inside face and an outside weathering face of 1/8-inch thick cement asbestos board covered with an epoxy matrix coating and stone aggregate to create an exposed aggregate appearance, Figure 3.14. Interior wall panels have plywood on both sides to which a finish surface such as gypsum wallboard is applied. An extruded aluminum frame serves as an edge member and spine channel for panel-to-panel joining, Figures 2.10g and h. A typical exterior panel weighs about 6-1/2 pounds per square foot and an interior panel about 3-1/2 pounds per square foot.

3.15 INNOVATIVE PANEL–CAST PLASTER/STEEL STUDS

Housing Manufacturer:
General Electric

Most interior wall and ceiling surfaces have joints that must be hidden or accented to create an attractive finished appearance. Either operation costs money and in the case of factory produced units may cause a manufacturing bottleneck. General Electric developed a structural wall and ceiling of plaster cast directly to steel framing into full length panels. This continuity eliminates the need for joint treatment and enhances fire resistance.

The specially formulated cast plaster used for the ceilings and sidewalks is 5/8 inch thick gypsum plaster, cast continuously on a moving belt and attached to the steel "C" shaped studs through punched shear keys in the flanges, Figures 3.15a and b. Plaster thickness can be increased to meet fire resistance requirements.

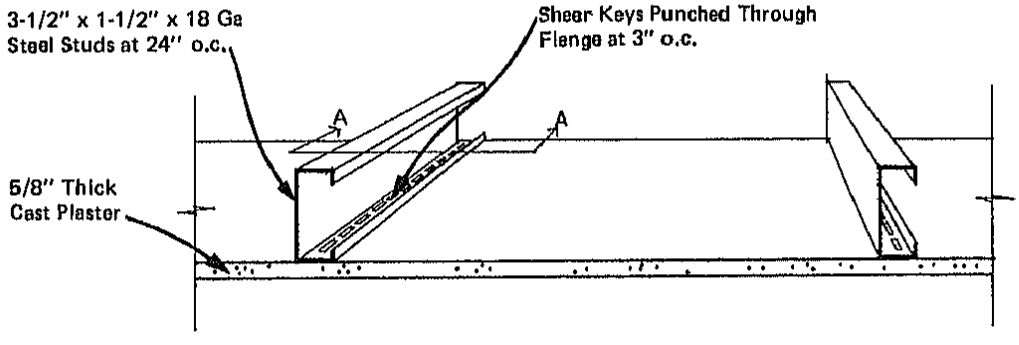


FIGURE 3.15a
CAST PLASTER/STEEL STUD PANEL

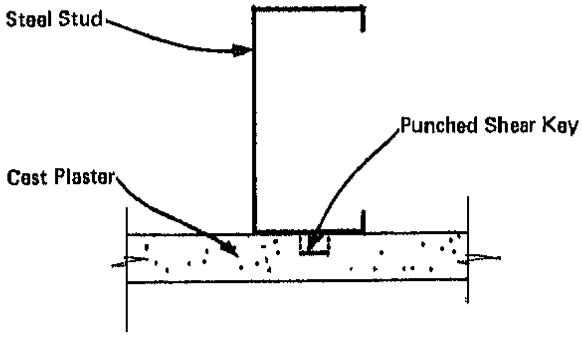


FIGURE 3.15b
SECTION A-A–THROUGH PUNCHED SHEAR KEY

3.16 INNOVATIVE PANEL– LIGHT GAGE STEEL CORE

Housing Manufacturer: Townland

The infill units placed on the mega-structure of the Townland system (see 1.8) are of steel panel construction with the usual studs replaced with load-bearing steel panels. A typical exterior wall panel consists of light gage steel channel sections with gypsum board interior surface and an exterior of plywood and cedar siding, Figure 3.16. Insulation is placed in the panel voids.

The panel material is precut at the factory, assembled on site and attached mainly with sheet metal screws.

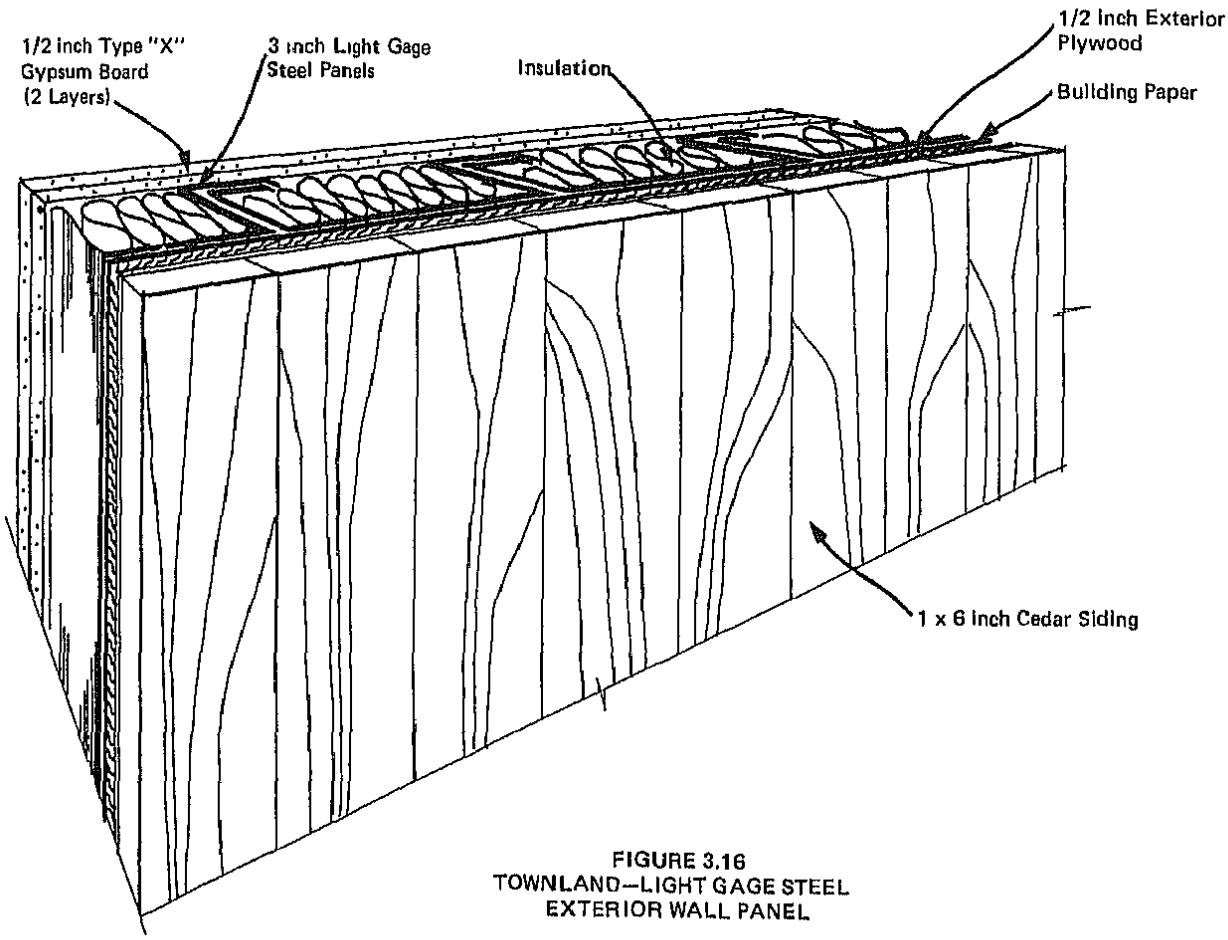


FIGURE 3.16
TOWNLAND–LIGHT GAGE STEEL EXTERIOR WALL PANEL

4.

INTERIOR ENCLOSURE

4.1 FIRE STOPPING AROUND OPENINGS

Housing Manufacturers:

FCE-Dillon
Levitt
TRW

Many times the precautions taken for fire proofing building assemblies are negated by the "leaks" around the edges of the assemblies, such as at doors and windows or through holes for electrical boxes, pipes, etc. The leaks can also permit sound transmission.

The fire stopping around doors used in the Dillon system consists of shims and glass fiber insulation packed into the space commonly left void between the door jamb and rough wall, Figure 4.1a. This was done where a 20 minute fire-rated door frame was required at the entrance to an apartment and where metal door frames were not utilized.

Galvanized sheet metal fire shields are used in the Levitt system to protect the inter-module joint, Figure 4.1b. The sheet metal fire shield is nailed to module A in the factory and to module B in the field.

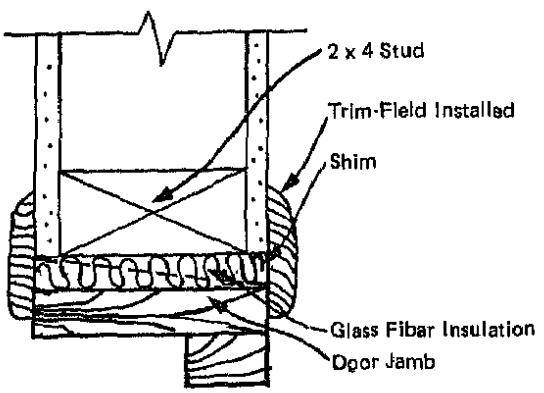


FIGURE 4.1a
FCE DILLON–FIRE STOPPING AROUND DOORS

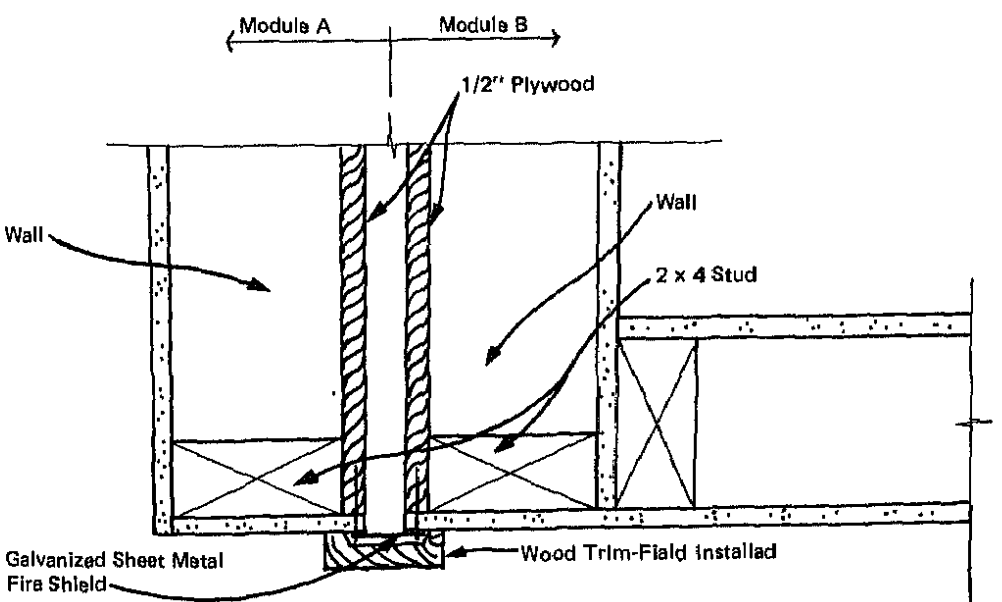


FIGURE 4.1b
LEVITT–SHEET METAL FIRE SHIELDS AT INTER–MODULE JOINT

4.1 FIRE STOPPING AROUND OPENINGS
continued

Holes for the passage of ducts and pipes through paper honeycomb sandwich panels used in the TRW system present a unique fire protection problem. To seal the panel against flame or heat penetration, the exposed paper is coated with a fire resistant plaster material and the void is packed with glass fiber insulation, Figure 4.1c.

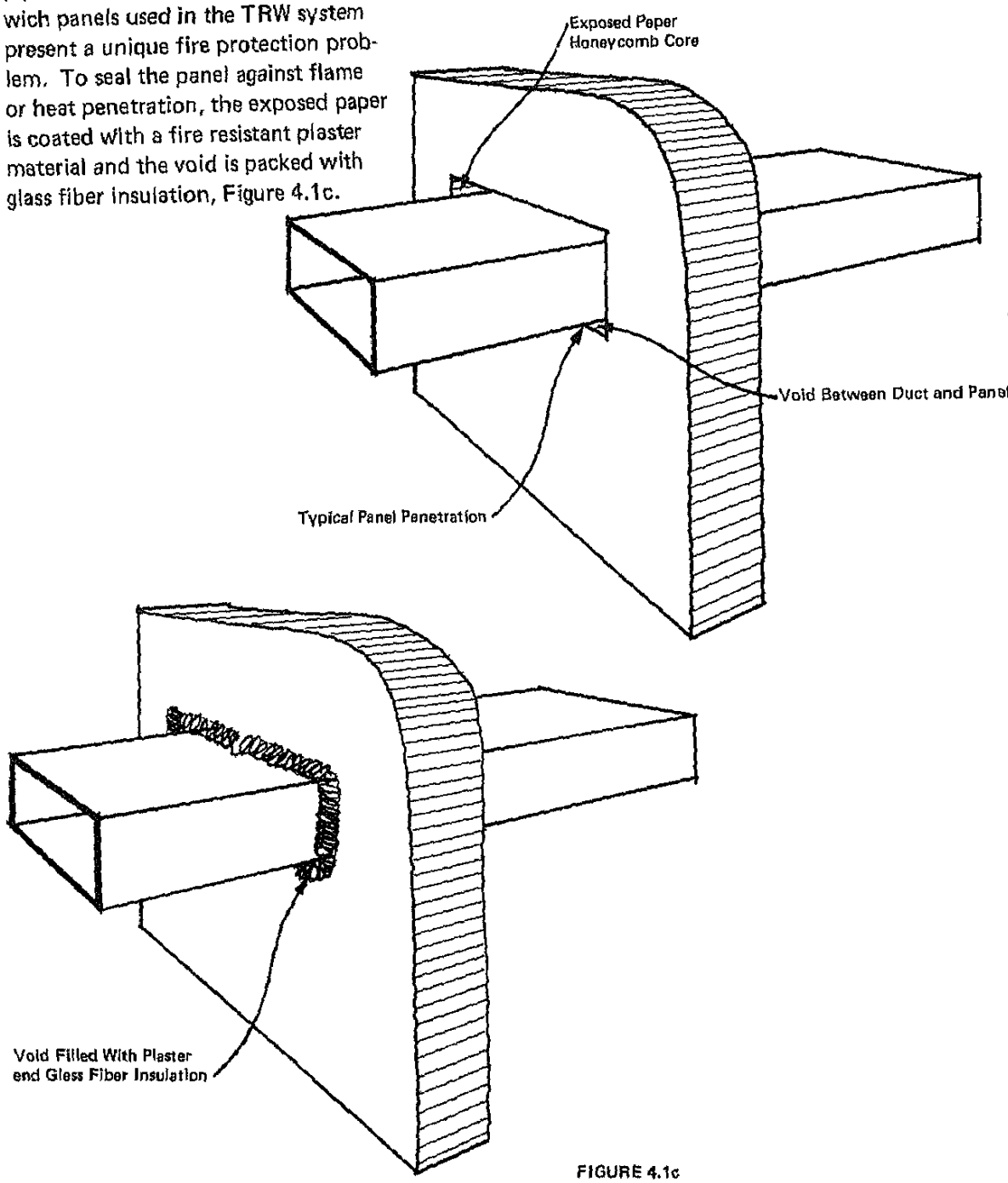


FIGURE 4.1c
FIRE STOPPING AROUND PANEL PENETRATIONS

4.2 SMOKEPROOF TOWER PRESSURIZED DURING FIRE

Housing Manufacturer:
Rouse-Wates

Guide Criteria for Operation BREAKTHROUGH included recommendations for smokeproof enclosures for buildings over six stories. Rouse-Wates utilized stair enclosures as "Pressurized Vertical Shafts". The air supply fan for the smokeproof stair enclosure was placed on the roof over the stairway. Weatherstripped doors maintained the pressure seal at openings. The pressurizing fan and the automatic-opening device on the grade-level door to the outside were connected to the building fire alarm system. Operation of the building fire alarm system automatically starts the fan and opens the grade-level exit door. The system is designed to keep smoke out of the stairway and to purge any smoke and heat that may enter.

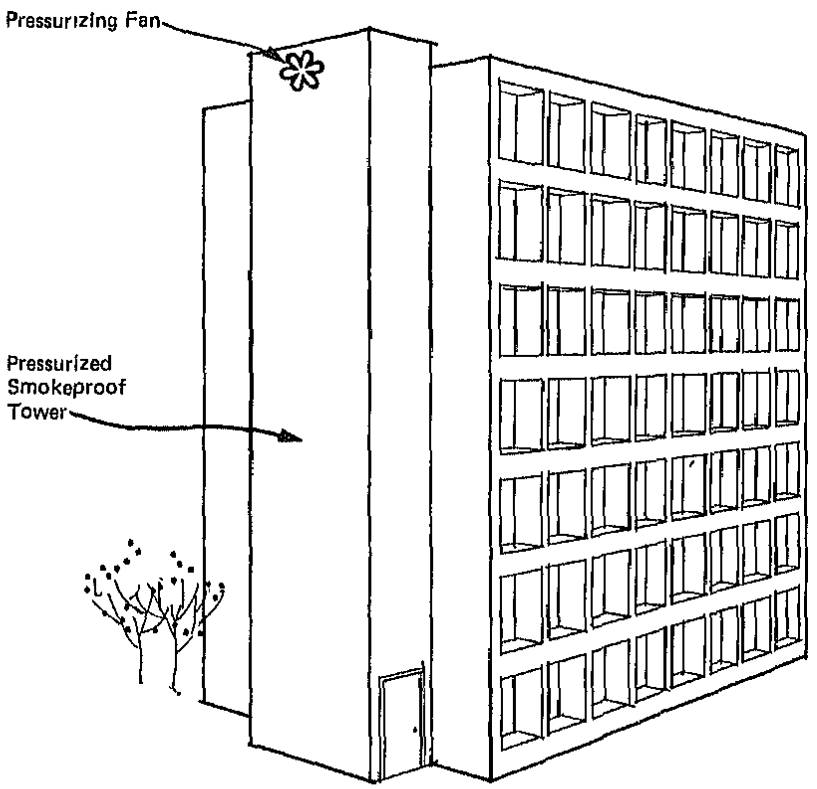


FIGURE 4.2
ROUSE WATES—PRESSURIZED SMOKEPROOF TOWER

4.3 BLOCKING SOUND PATHS BETWEEN DWELLINGS

Housing Manufacturer: Levitt

The location of a party wall separating two dwellings within a module (see 2.3) presents a unique acoustical problem. Plywood subflooring runs continuously under the party walls providing a sound transmission path between dwellings.

Sound insulation is improved by breaking the continuity of the subfloor with a saw kerf between the party walls and installing insulation in the floor/ceiling cavity, Figures 4.3a and b. This insulation also provides resistance to fire spread between dwellings.

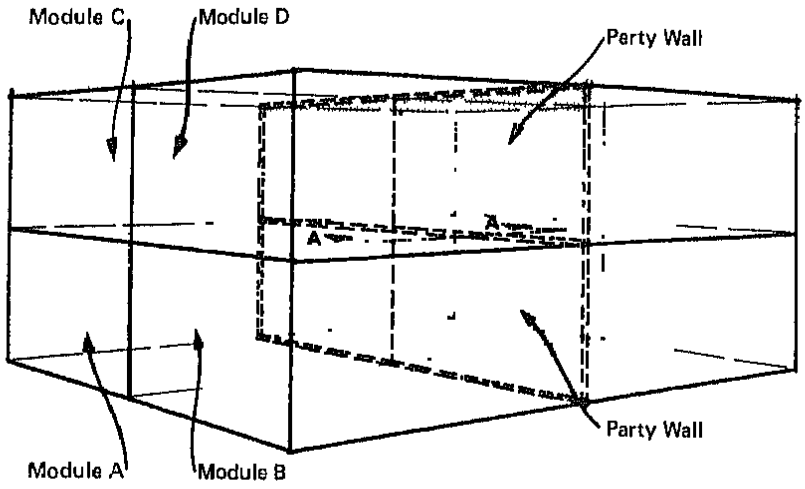


FIGURE 4.3a
PARTY WALL WITHIN MODULES

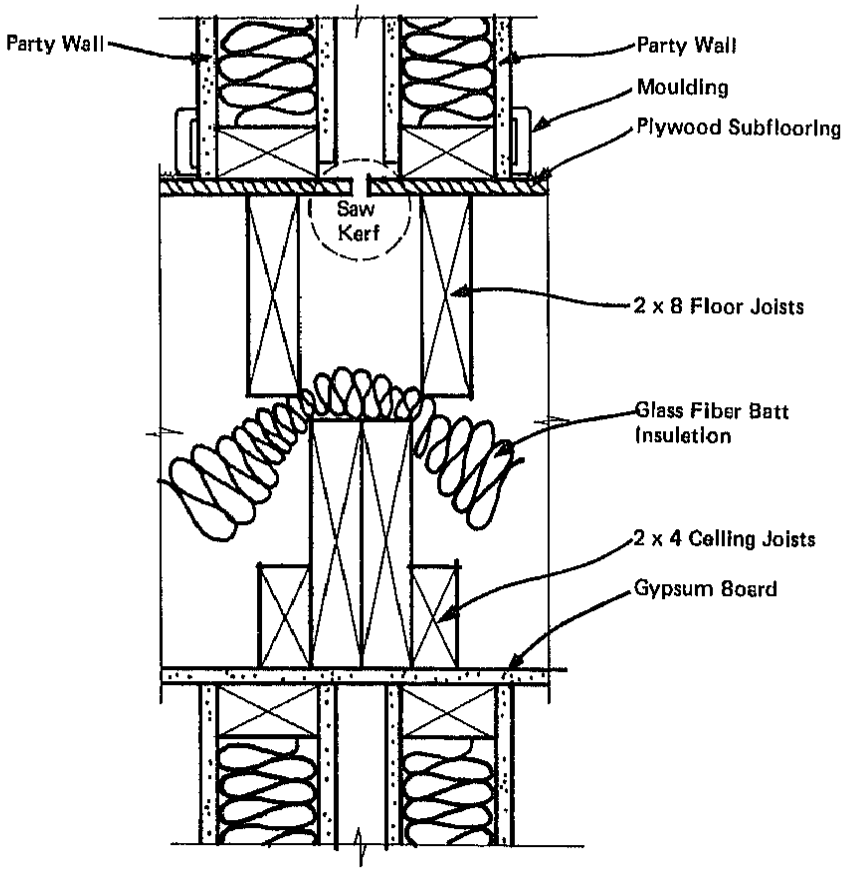


FIGURE 4.3b
SECTION A-A—THROUGH FLOOR/CEILING ASSEMBLY AT PARTY WALL

4.4 DECREASING NOISE TRANSMISSION BETWEEN DWELLINGS

Noise transmission between multi-family dwellings often occurs despite careful installation of sound-attenuating assemblies. Installation of electrical boxes, heating ducts or other penetrations provide flanking paths for the sound which can nullify other precautions and provide paths for fire travel from dwelling to dwelling, Figure 4.4a.

Multi-family housing producers have attempted to eliminate the sound transmission problem by packing electrical boxes, ducts or other small holes with elastic non-setting caulk or glass fiber insulation, Figure 4.4b. This also has the added advantage of aiding fire endurance.

It should also be noted that when heating penetrations are back-to-back at a party wall, it is better to locate them several stud spaces apart rather than in the same stud space for both fire and acoustical reasons.

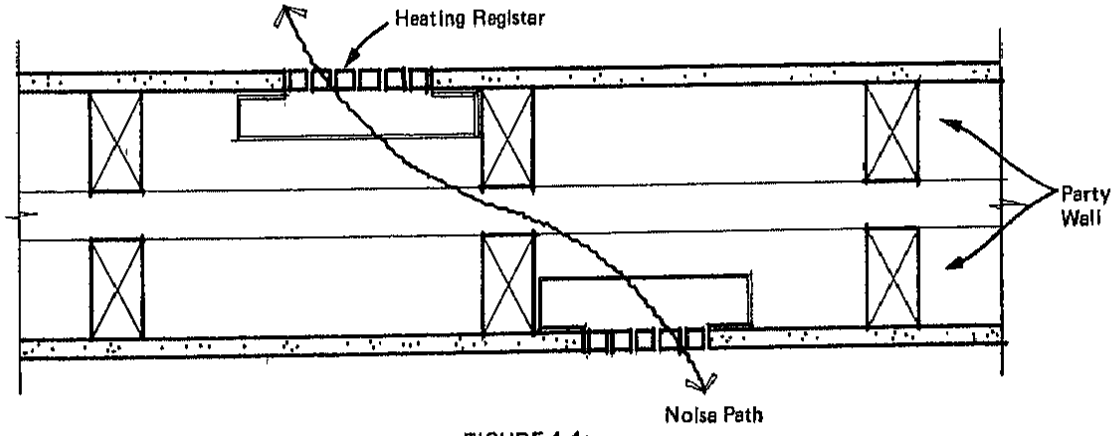


FIGURE 4.4a
FLANKING PATHS FOR SOUND DUE TO WALL PENETRATIONS

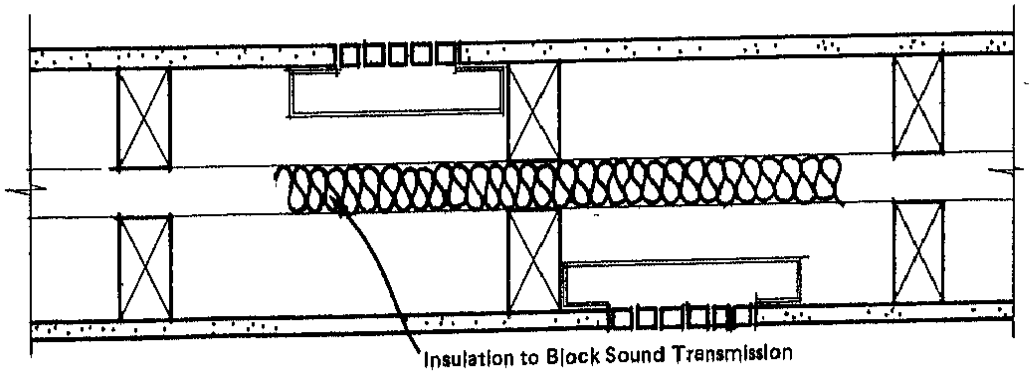


FIGURE 4.4b
USE OF INSULATION TO BLOCK SOUND TRANSMISSION

4.5 GYPSUM BOARD BACKING OF PLASTIC TUB/SHOWER UNITS

Housing Manufacturers:
National Homes
(used also by other HSPs)

The use of one-piece glass fiber reinforced polyester tub/shower units eliminates the need for a backing surface for a waterproof finish. However, acoustic and fire safety considerations negate this solution for some types of housing. Gypsum board was selected as backing material since it resists sound transmission and provides fire resistance.

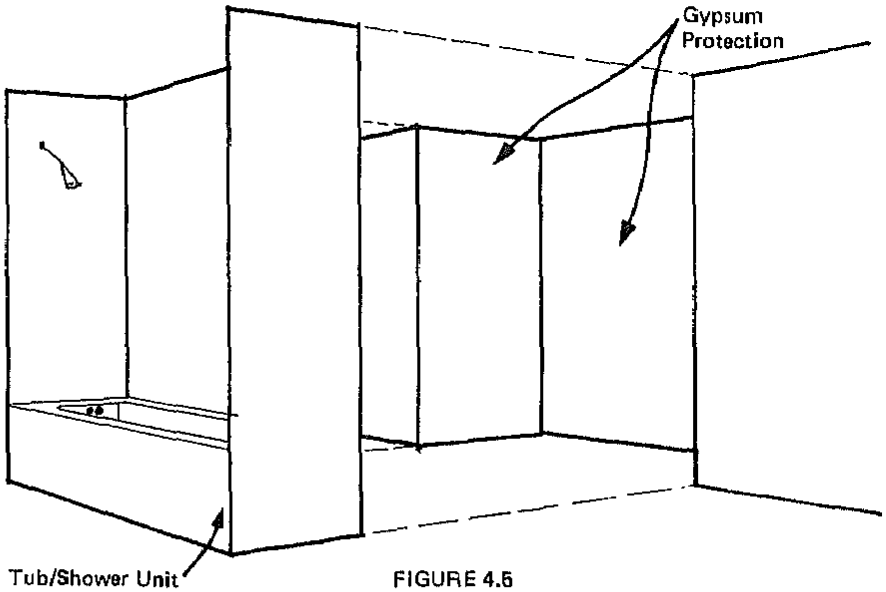


FIGURE 4.6
PLASTIC TUB/SHOWER UNITS

4.6 ELIMINATING CRACKS OVER WINDOWS AND DOORS

Housing Manufacturer:
Home Building Corp.

Volumetric modular units can be subjected to severe local stress conditions during fabrication or transportation to the site and its associated loading/unloading operations. This quite often leads to crack development in the drywall over windows and doors, Figure 4.6a. This problem is minimized by placing architectural plywood accent panels over all windows and doors to introduce a controlled vertical crack which can be hidden by molding, Figure 4.6b.

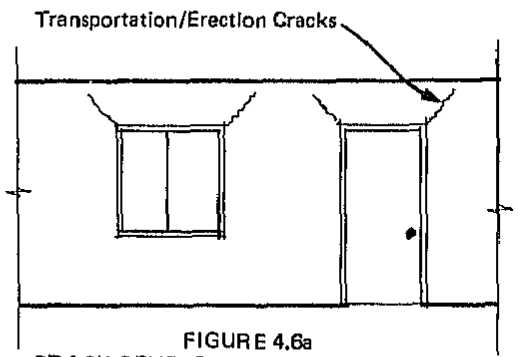


FIGURE 4.6a
CRACK DEVELOPMENT OVER WINDOWS ANO DOORS

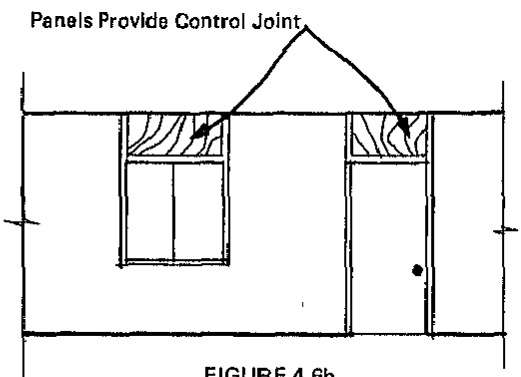


FIGURE 4.6b
PLYWOOD ACCENT PANELS INTRODUCE CONTROLLEO VERTICAL CRACK

4.7 SPACE-SAVING ROUTED HANDRAIL

Housing Manufacturer: Pantek

The stair handrail is usually an add-on accessory to the wall. However, in this system, the recessed handrail is an integral part of the wall, Figure 4.7. This solution is especially useful where the stairwell width is narrow and every inch counts.

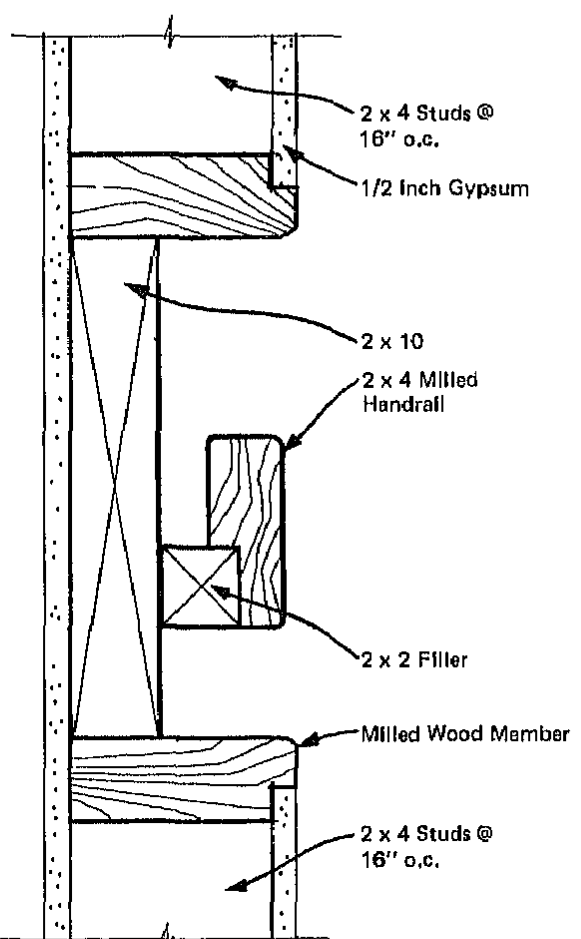


FIGURE 4.7
HANDRAIL DETAILS

5.

HVAC

5.1 ATTIC SPACE PROVIDES RETURN AIR PLENUM

Housing Manufacturer:
Home Building Corp.

The space provided above the site assembled hall (see 1.3) by the addition of a dropped ceiling is used as a return air plenum. A main trunk or supply plenum is located in the floor of the hall from which individual room supplies are tapped. Air is returned through a ceiling grill in the hall to the return air plenum which communicates with the furnace.

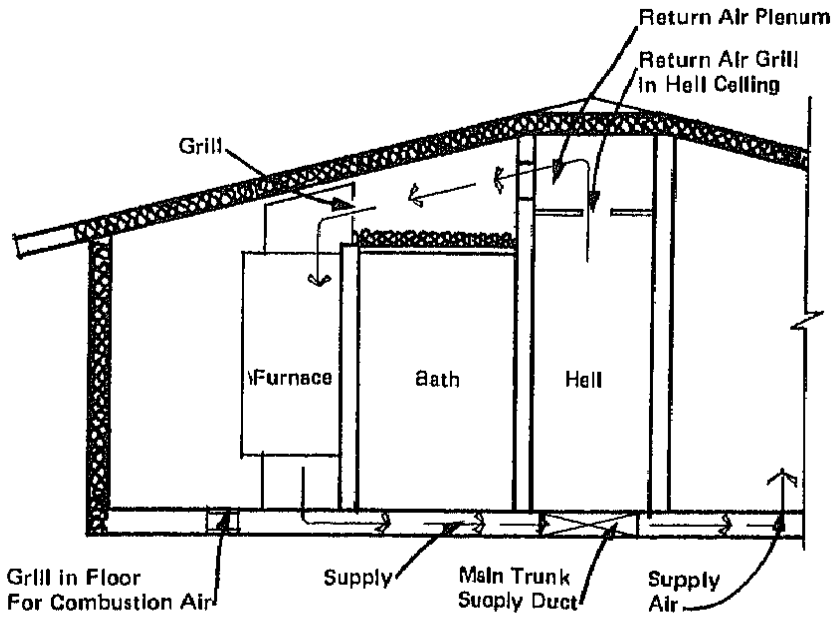


FIGURE 5.1
ATTIC SPACE PROVIDES RETURN AIR PLENUM

5.2 SERVICE MODULE CEILING JOISTS ALLOW PIPE PLACEMENT

Housing Manufacturer: Alcoa

The service modules used in this housing system contain a concentration of mechanical services which requires that wiring, piping and ducts pass through the ceiling structure. Open web trusses allow horizontal distribution of mechanical, plumbing and electrical components. The truss consists of 2 x 2 wood chord members connected with spaced plywood web plates. Staples and adhesives are used for attaching web members to the chords.

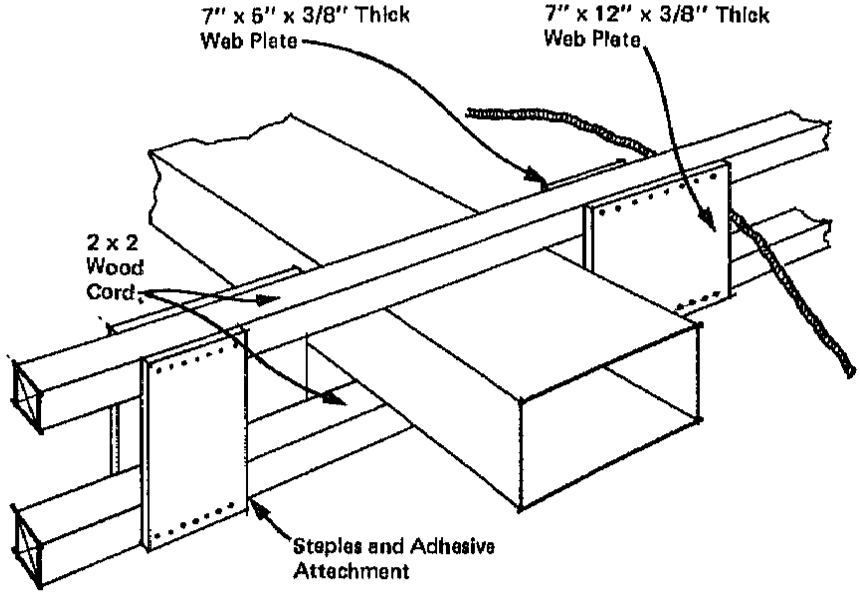


FIGURE 5.2
SERVICES PASS THROUGH OPEN WEB WOOD TRUSS

5.3 EXTERIOR MOUNTED HEATING AND AIR CONDITIONING UNIT

Housing Manufacturer:
Republic Steel

This housing system as described in 1.7 and 2.6 uses an individual heating, air conditioning and distribution system for each module which permits zone control for thermal comfort. A unique feature of the system is the placing of a self-contained package combining heating and cooling outside the module thus conserving inside floor space and reducing inside noise, Figure 5.3a. The unit is mounted to the grade beam at the bottom of the outside wall at one end of each module and requires no chimney nor flue.

The interior of the grade beam acts as supply and return air ducts for the air distribution system, thereby eliminating additional duct work. As shown in Figure 5.3b,conditioned air is supplied to the grade beam duct on one side of the module and is returned in the grade beam duct on the other side.

The air distribution system for each module consists of six supply registers which are individually adjustable. The return air system consist of five non-adjustable registers. The system features easy maintenance because of accessibility. If necessary, the entire HVAC unit can be easily lifted off the transition duct mounting and replaced by another unit.

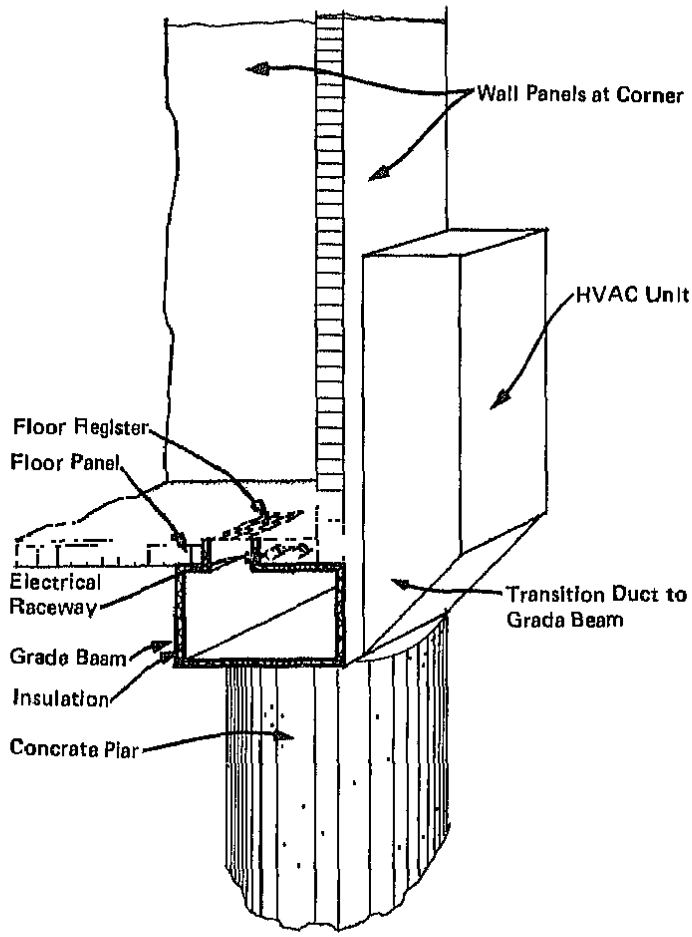


FIGURE 5.3a
SECTION A-A—EXTERIOR MOUNTED HEATING AND AIR CONDITIONING UNIT

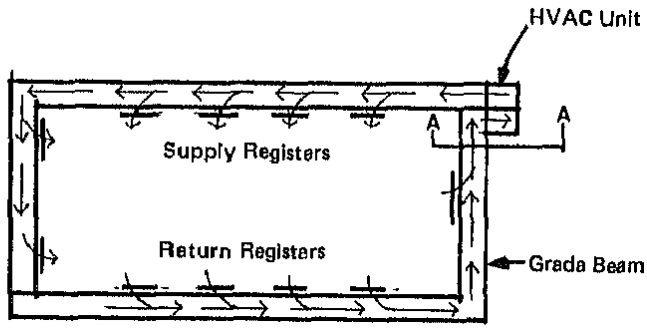


FIGURE 5.3b
AIR DISTRIBUTION SYSTEM IN EACH MODULE

5.4 CONNECTING SUPPLY AIR DUCTS IN STACKED MODULES

Housing Manufacturer:
National Homes

In volumetric modular construction, the lowering of one module onto another causes the joining of services to be quite difficult because of access limitations. After the lower module is placed, it is necessary to coordinate movement of the upper module horizontally in all directions and vertically to insure proper alignment, Figure 5.4a.

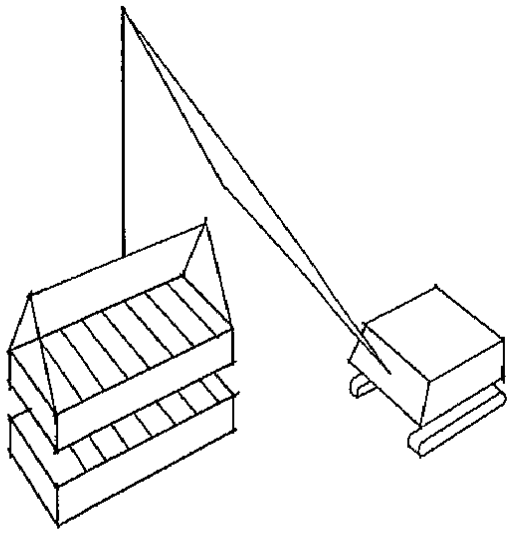


FIGURE 5.4a
PLACEMENT OF MODULAR UNITS

National Homes uses a solution in which an oversize sheet metal sleeve in the floor system of the upper module is place over an air distribution box setting on the ceiling joists of the lower module, Figure 5.4b. The distribution box has an elongated opening which allows some alignment tolerance in the horizontal direction without affecting the efficiency of the connection. The weight of the upper module insures a tight fit between the sleeve and the polyurethane gasket on the top surface of the distribution box. Conditioned air is delivered to the upper module through a floor register and to the lower module through a ceiling register.

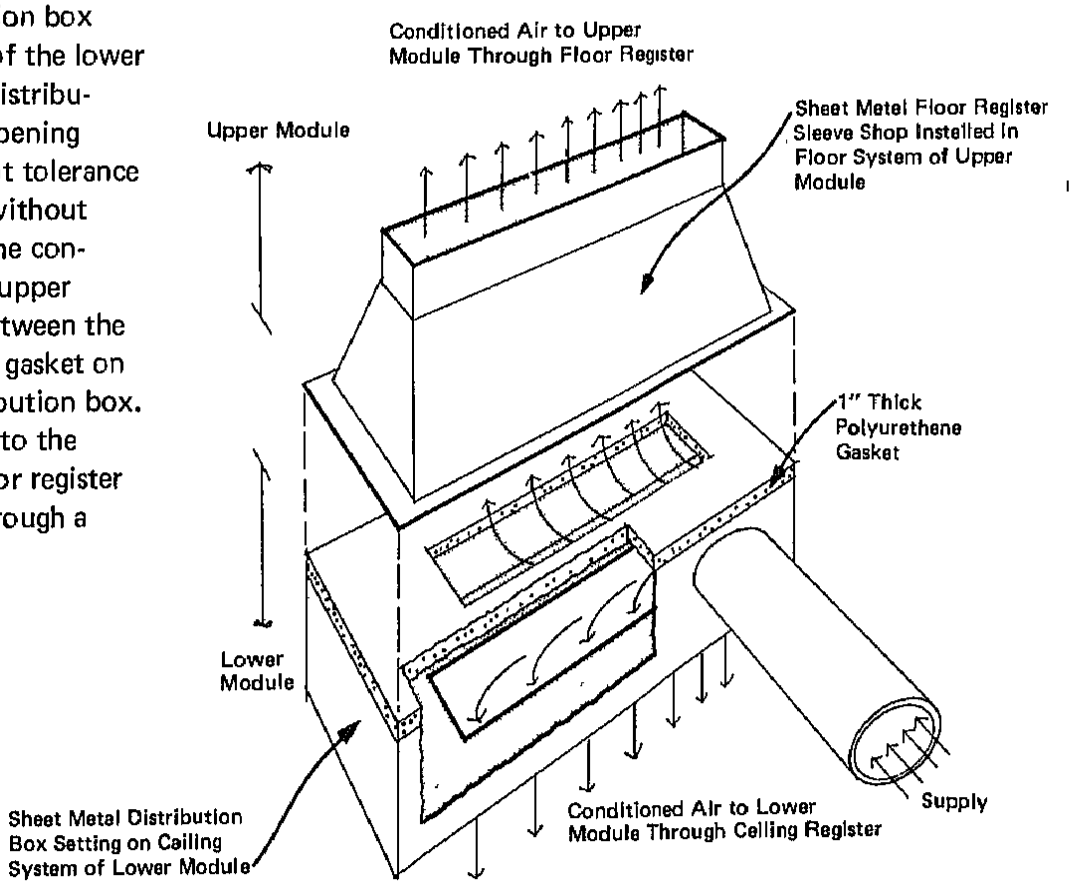


FIGURE 5.4b
CONNECTING SUPPLY AIR DUCTS IN STACKED MODULES

5.5 INTERIOR HEAT REGISTER THROWS HEAT TO EXTERIOR WALL

Housing Manufacturer:
FCE-Dillon

A two-pipe, central hot and chilled water distribution subsystem is used by FCE-Dillon for heating and cooling. The subsystem consists of fan coil units which are installed in the ceiling of each mechanical core module in the factory. The fan coil units discharge high velocity air through slot diffuser registers in the module which are flush with the ceiling.

The high velocity conditioned air is carried to the outside wall through a process called the "Coanda Effect". The rapid movement of air from the outside creates a negative pressure by entrapping the air in the space between the air stream and the ceiling. The resulting pressure differential causes the stream to follow the ceiling until velocity slows near the opposite wall. Gradually, induced room air mixes with the stream, tempering the air supply before it reaches the occupied space.

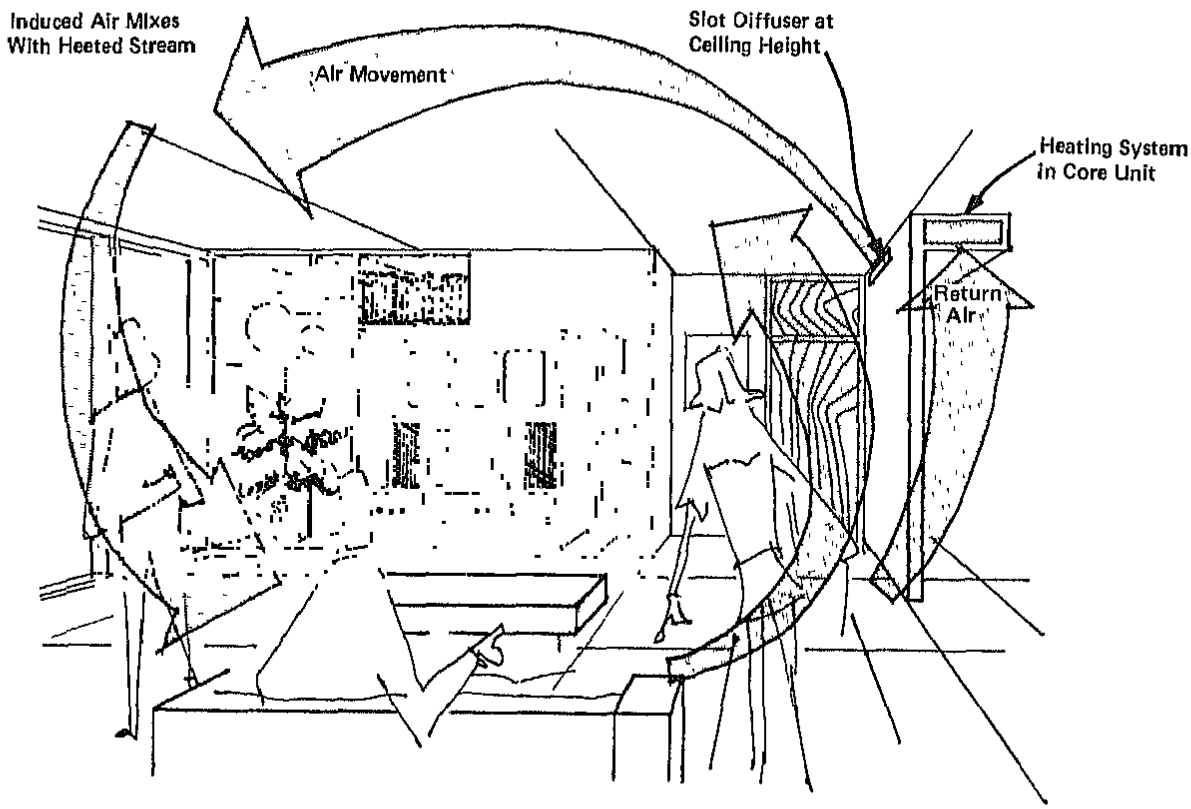


FIGURE 5.5
AIR MOVEMENT DUE TO THE "COANDA EFFECT"

5.6 PRE-PACKAGED MECHANICAL PENTHOUSE

Housing Manufacturer:
FCE-Dillon

A prepackaged penthouse for mechanical facilities is a feature of this system. This penthouse is built with a structural framework and is pre-plumbed and pre-wired. It can be custom-assembled to provide the domestic hot water supply, heating boilers and air conditioning equipment for the apartment units, corridors and public areas as needed in a particular building. The penthouse unit is sized to meet building demand and can be lifted to the roof and attached to the mechanical distribution system with a minimum of on-site labor.

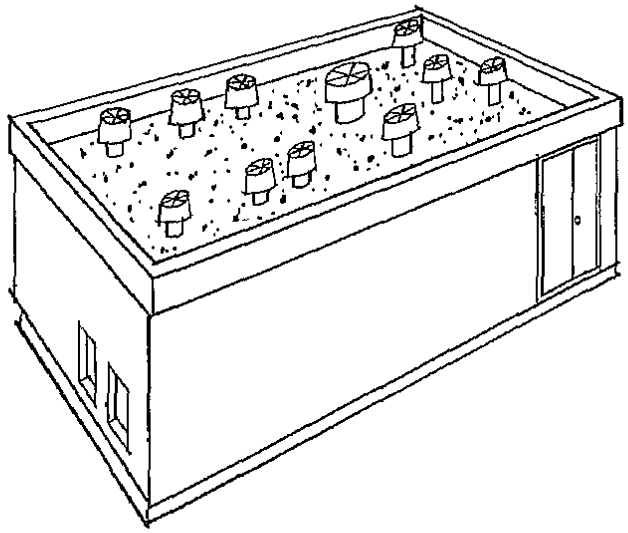


FIGURE 5.6a
PRE-PACKAGED MECHANICAL PENTHOUSE

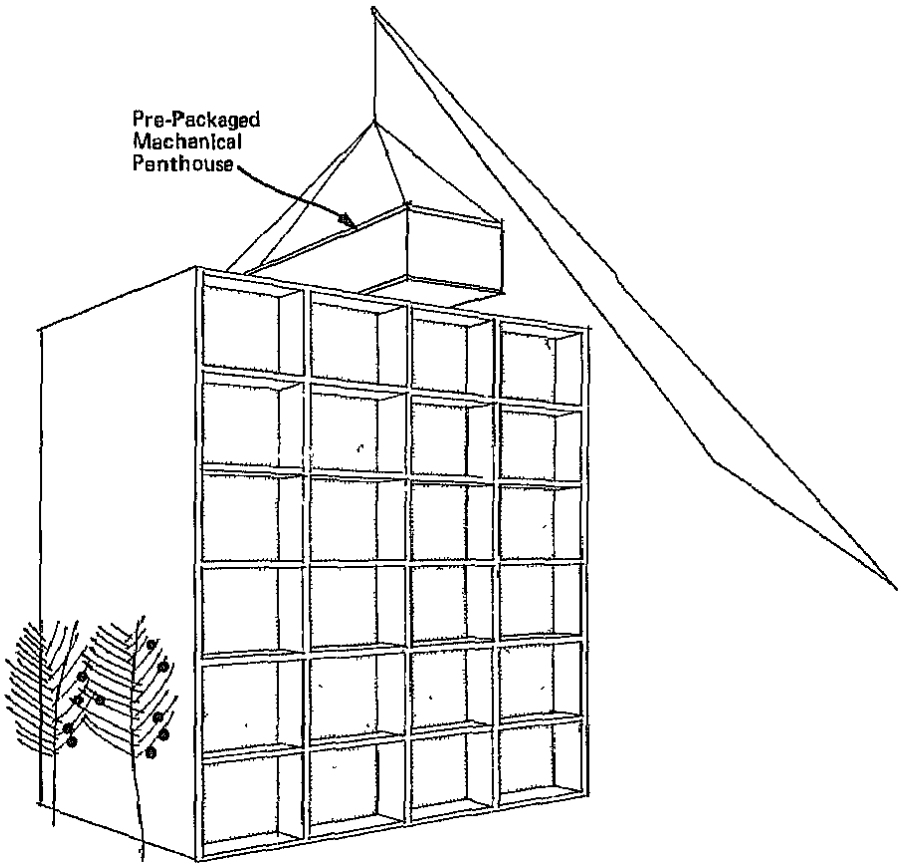


FIGURE 5.6b
PENTHOUSE UNIT PLACED ON ROOF

6.

PLUMBING

6.1 SILENCING PLUMBING NOISES WITH PLASTIC FOAM INSULATION

Housing Manufacturer:
Shelley

One annoying source of noise, especially in multi-family dwellings, is that caused by the plumbing system. Urea formaldehyde foam insulation is used for sound attenuation within the plumbing wall. After the plumbing assembly is installed and tested, it is oversprayed with the urea formaldehyde insulation to attenuate the noise at its source.

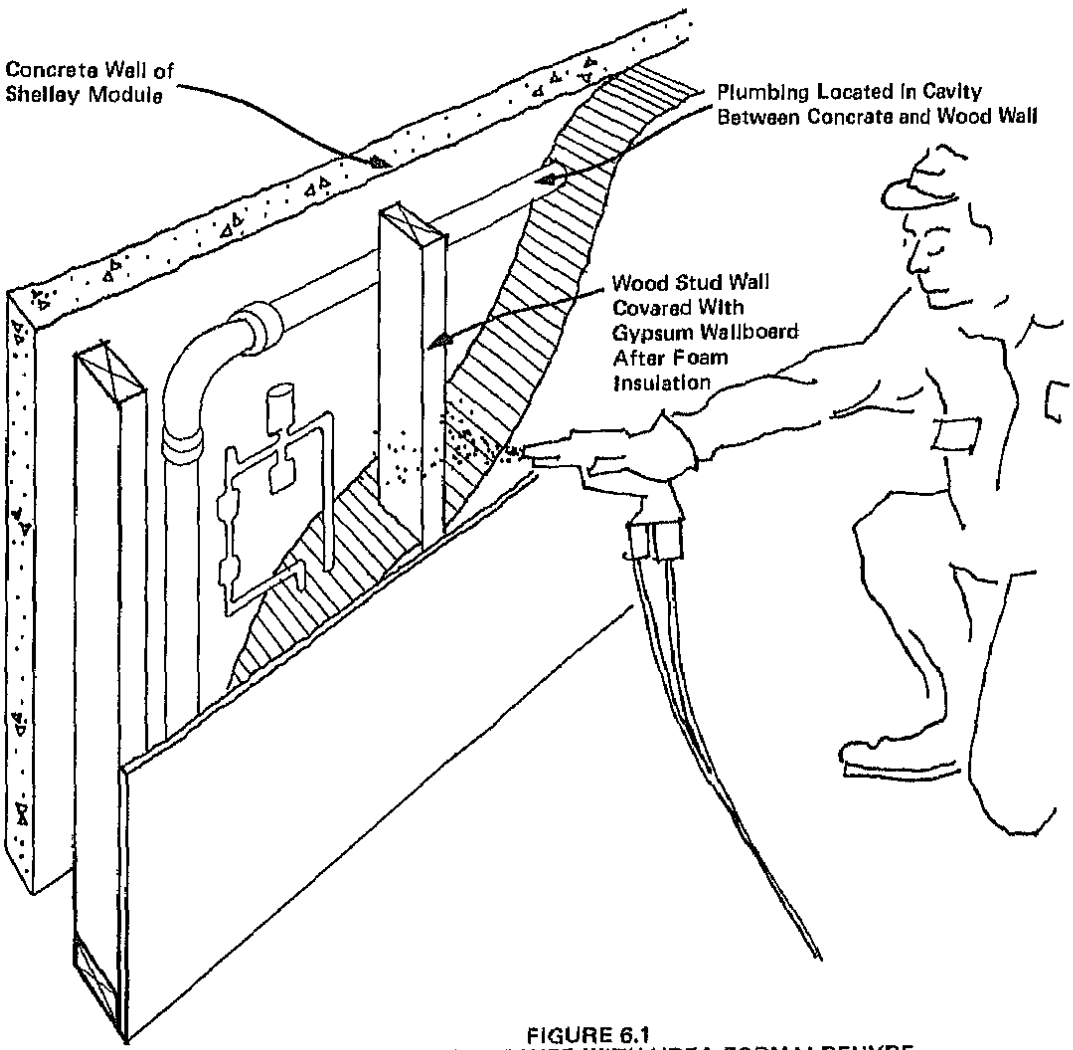


FIGURE 6.1
PLUMBING WALL SPRAYED WITH UREA FORMALDEHYDE FOAM INSULATION

6.2 SINGLE STACK PLUMBING SYSTEM

Housing Manufacturer:
FCE-Dillon

A one-stack plumbing system is being used by FCE-Dillon. This plumbing system does not require a separate vent stack, branch vents nor individual fixture vents but uses the same drain stack sizing as conventional, two-pipe systems for the same loads. The main feature of the single-stack system is the use of the wastewater stack to relieve pneumatic pressure fluctuations through the same pipe in which waste is carried down to the sanitary sewer. Since separate venting is not required, it takes less material and time to install, requires less space and has design characteristics which are compatible with industrialized housing. For example, fewer connections are required between modules.

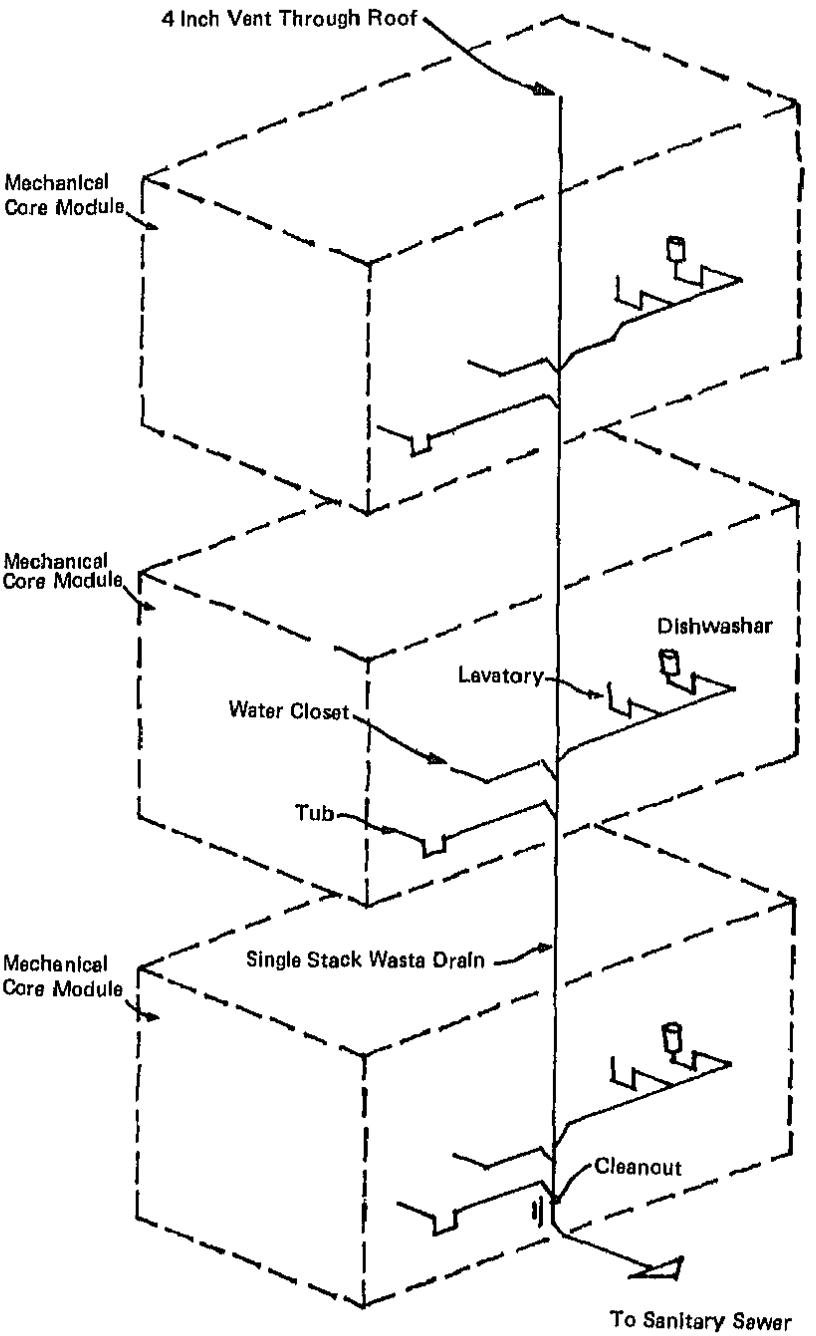


FIGURE 6.2
SINGLE STACK PLUMBING SYSTEM

6.3 PREFABRICATED MECHANICAL CORE MODULE

Housing Manufacturer: Alcoa

Single-story, stackable mechanical core modules are used in this system, Figure 6.3a. They include a kitchen, one or more bathrooms, laundry facilities, stairway and principal elements of plumbing, heating, ventilating, air conditioning and electrical services, Figures 6.3b.

After being transported to the site, the modules are erected on the prepared foundation in one- or two-story configurations and the panelized house is built around. As shown in 5.2, a special system of joists is used in the ceiling structure to allow free horizontal distribution of mechanical, electrical and plumbing services. The modules are packaged in weatherproof covering for transportation and protection until the building is enclosed. Mechanical core modules are delivered with framing exposed on the outside to allow on-site mechanical and electrical continuity and to facilitate matching of field coverings and finishes from the service module to adjacent panels.

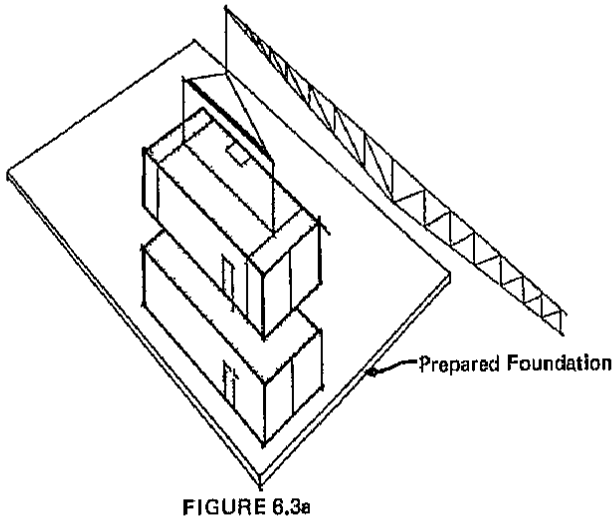


FIGURE 6.3a
MECHANICAL CORE MODULES PLACED TWO HIGH

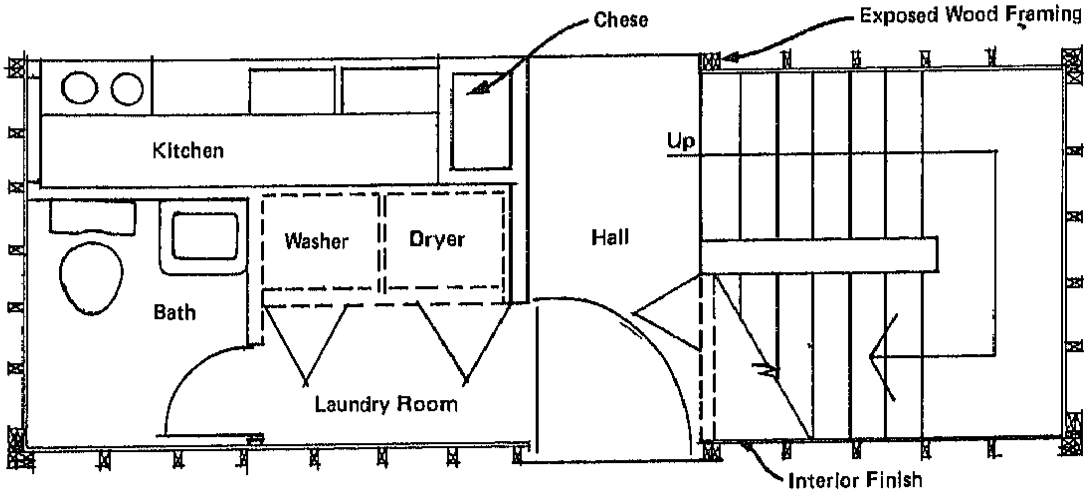


FIGURE 6.3b
FLOOR PLAN–MECHANICAL CORE MODULE WITH STAIRS

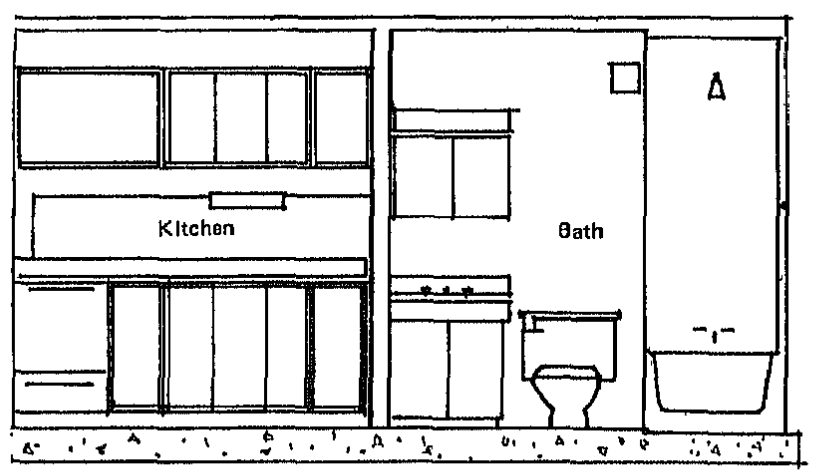
6.4 MECHANICAL CORE MODULE FOR PRE-CAST CONCRETE PANEL SYSTEM

Housing Manufacturer: FCE-Dillon

A factory-built service and utility component, called a mechanical core module, which reduces site labor costs and construction time is used in this high-rise concrete panel system. See 1.5 for relationship of module to the typical floor plan. The mechanical core module contains a kitchen, bathroom and wetwall service chase. The service chase includes all the central mechanical and electrical connectors for each unit. The floor of the module is an 8 inch thick concrete slab.

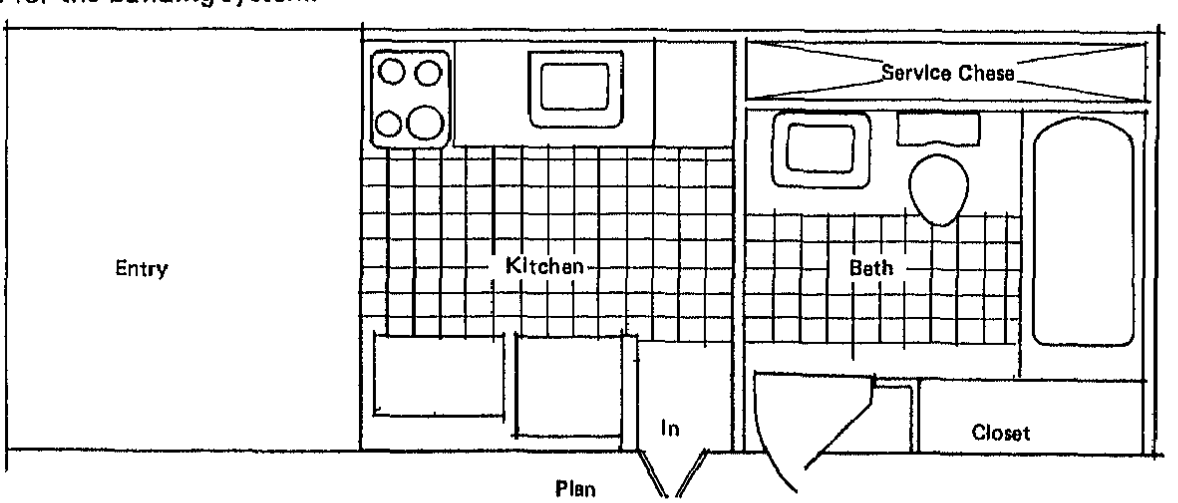
The module is delivered to the building site completely finished, with factory-installed fixtures and equipment. These include: refrigerator; range; sink; garbage disposal; kitchen cabinets; closets; a bath and shower; water closet; lavatory; flooring; light fixtures; heating and air conditioning equipment. The module contains all the electrical panels and cables for making the connections to the building's electrical supply system, and to provide the cable or conduit for the particular apartment's outlets, switches, electrical fixtures, telephone service, TV antenna connections and communications equipment.

All plumbing and heating equipment, as well as central electrical and communications connections, are connected to pipes, conduit, venting stacks and ducting in the module's wetwall service chase. During building erection, the module is easily connected to pipes, conduit and ducting. Connection of the various services at the mechanical core module's wetwall service chase from floor to floor reduces on-site labor to a minimum.



Elevation

See 2.16 for a description of the erection sequence for the building system.



Plan

FIGURE 6.4
FCE-DILLON—MECHANICAL CORE MODULE

6.5 EXTERIOR UTILITY ENCLOSURE PROVIDES ACCESS TO TRAPS AND DRAINS

Housing Manufacturer:
Republic Steel

This housing system is site erected from panels as discuss in 1.7. However, the bathroom subsystem is a totally integrated factory produced module containing bathtub, water closet and lavatory with associated water supply and waste fittings.

Exterior access to both the traps and drains is provided by a utility enclosure attached to the outside of the wall panel, Figures 6.5a and b. Wastewater is taken from the bath through the wall and into the soil pipe which leads to the sewer system. The removable enclosure door provides the necessary access for cleanout and maintenance. Electric heat tape is wrapped around the pipes to prevent freezing when required by weather conditions.

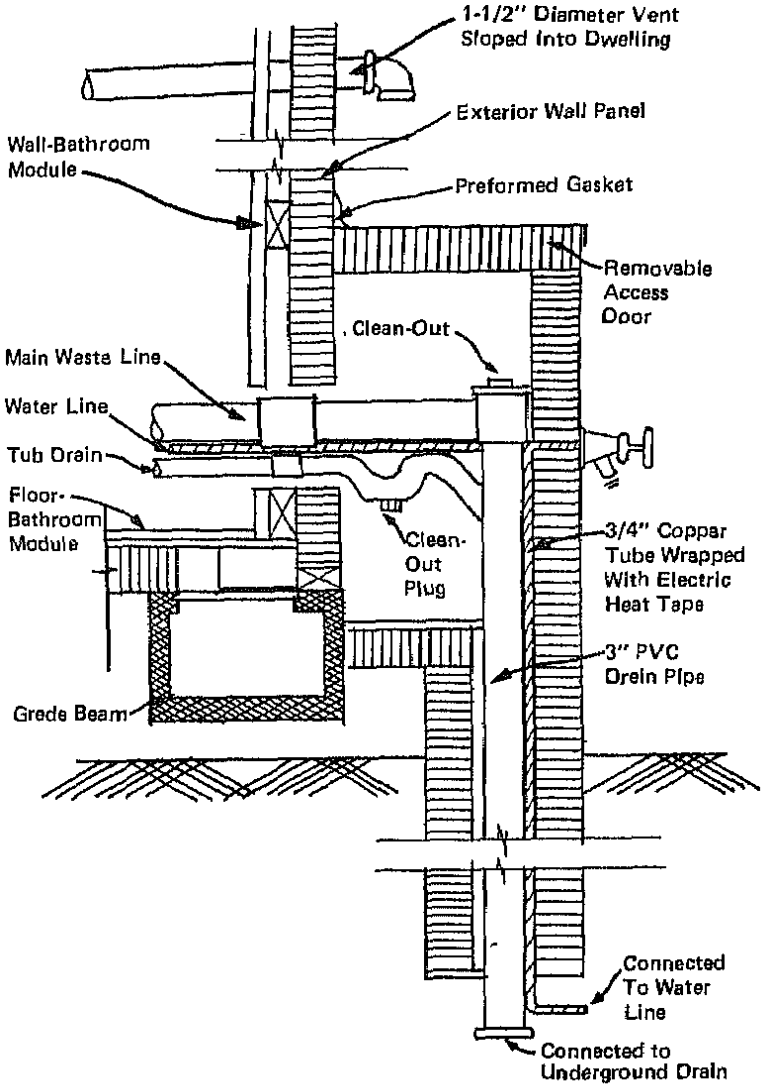


FIGURE 6.5b
SECTION A-A–UTILITY ENCLOSURE ATTACHED TO EXTERIOR OF HOUSE

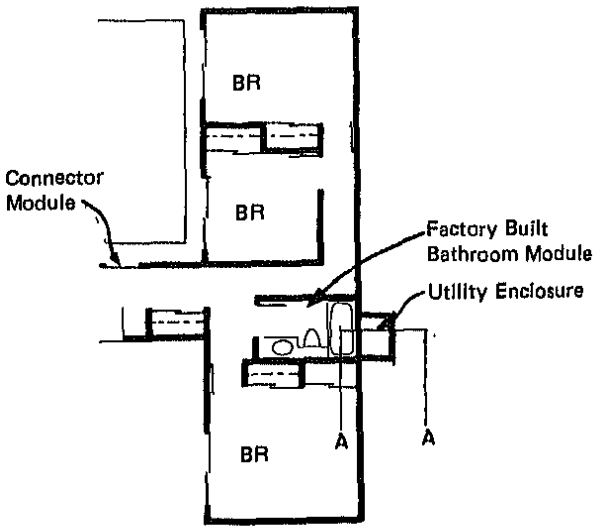


FIGURE 6.5c
FACTORY BUILT BATHROOM MODULE

6.6 REDUCED VENTING/ PLUMBING SYSTEM

Housing Manufacturer:
Republic Steel

Republic's single-story, single-family detached system uses reduced venting plumbing. A 1-1/2 inch diameter vent pipe projects horizontally through a side wall, Figure 6.6. The pipe is sloped to drain any condensate to the inside of the house and prevent the pipe from freezing or otherwise restricting the venting function. This venting arrangement, because of the potential odor, is best used away from exterior activity areas.

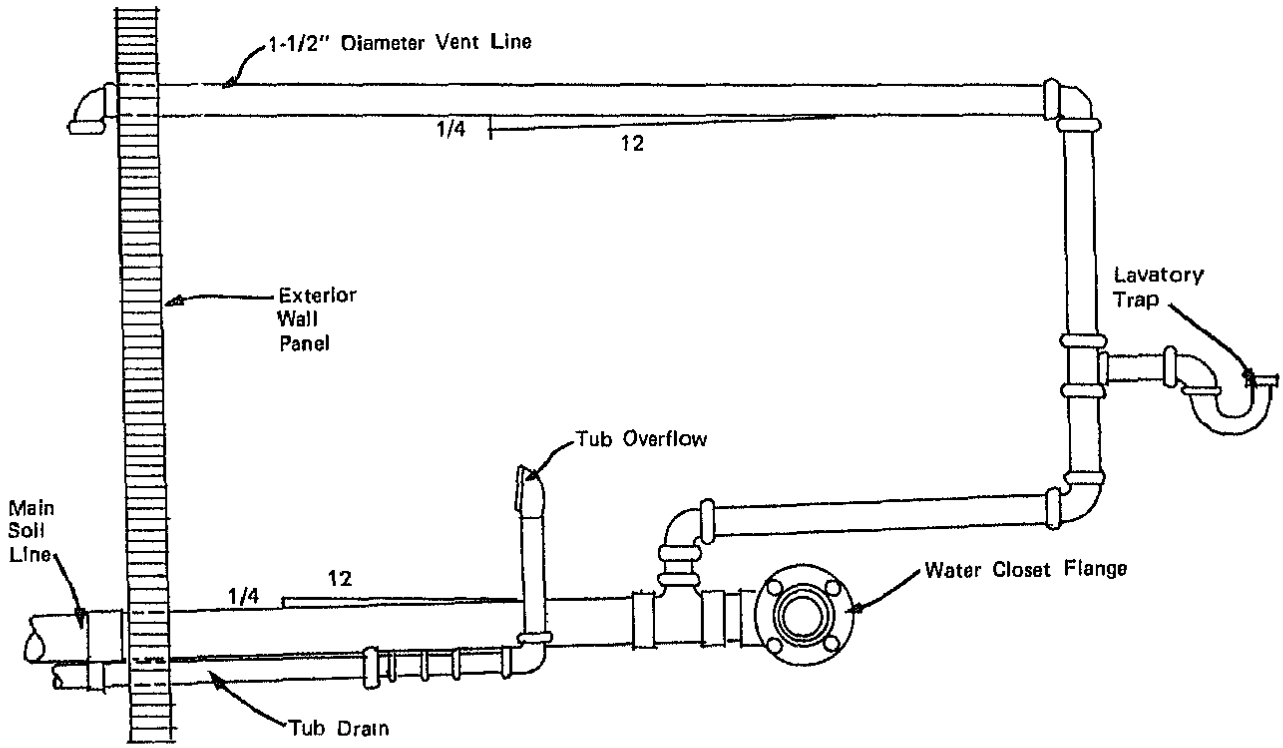


FIGURE 6.6
REPUBLIC STEEL—WASTE AND VENT SYSTEM

6.7 PREFABRICATED KITCHEN MODULE

Housing Manufacturers:
Republic Steel
Rouse-Wates

The kitchen module used in the Rouse-Wates precast concrete panel system is a prefabricated wooden structure consisting of two appliance walls and a dropped ceiling site built between walls which conceals electrical, plumbing and exhaust duct crossover networks, Figure 6.7a. All major appliances are included such as range, refrigerator, disposal, hood, dishwasher, and water heater. Each module has an electrical load center mounted in the back wall which is prewired for all electrical components. All plumbing necessary to connect appliances, incoming supply lines and drain lines is included. A flexible metal air exhaust duct from the hood is provided for on-site connection to the service chase. For shipping and erection purposes, the two appliance walls in each module are pushed together to form a protected box. Packaging materials are used to prevent shipping damage, racking during lift, and both over-the-road and within-the-building weather protection.

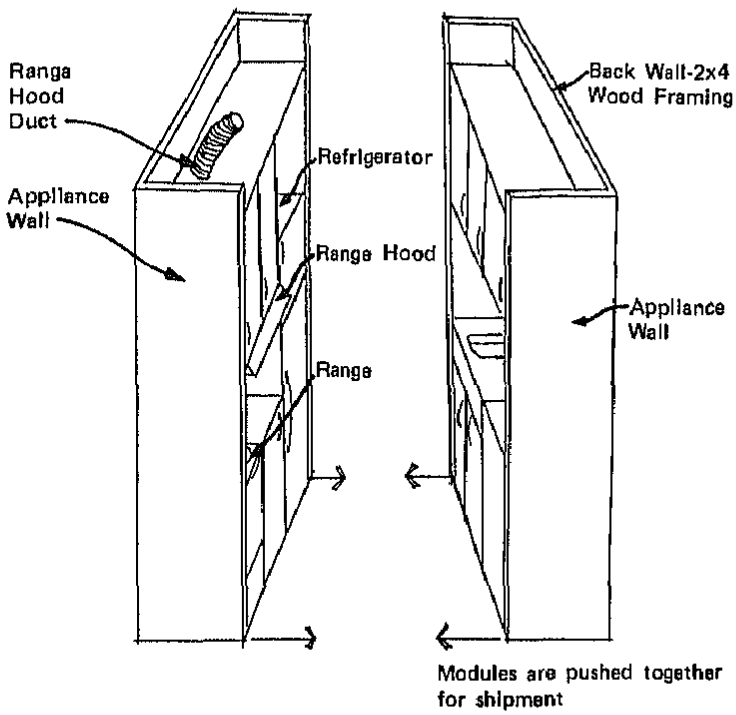


FIGURE 6.7a
ROUSE WATES—KITCHEN MODULE

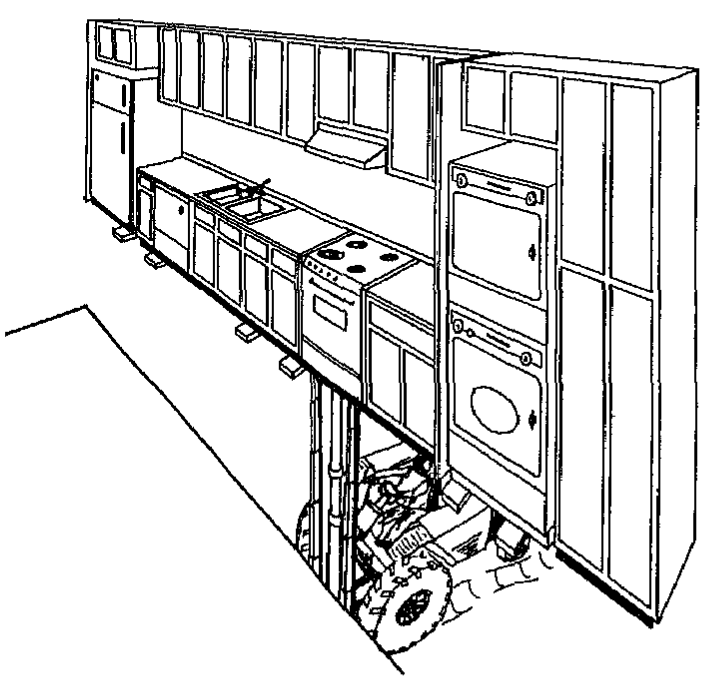


FIGURE 6.7b
REPUBLIC STEEL—KITCHEN/LAUNORY MODULE

The Republic Steel Prefabricated Kitchen-Laundry module represents a unique subsystem design for industrialized housing. All the kitchen appliances, the washer and dryer units, and the water heater are completely assembled, prewired, preplumbed in the factory before the module is shipped to the job site as a unit. The only job site work is single point hook-up of water, sewer and electrical services.

6.8 KITCHEN MODULES FOR HIGH-RISE CONCRETE SYSTEM

Housing Manufacturer:
Descon/Concordia

Descon/Concordia kitchen modules contain all appliances, counter tops, cabinets, lighting and plumbing which are associated with any conventionally built kitchen, Figure 6.8. Modules can be combined to provide a variety of kitchen arrangements from galleys to "L" shaped dining-kitchen types.

The structural system of the module is non-load bearing in service and is designed to resist only forces encountered during transportation and erection. Back and side walls are constructed of wood or metal studs which have an interior finish and exterior finish dependent on finish requirement in the apartment. All plumbing, electrical and mechanical sub-systems are enclosed in a special closet inaccessible except to tradesmen and maintenance crews and containing all materials, ready for connection between units, floor to floor. The unit rests on a floor with toe space under the cabinets and appliances only. The remaining kitchen floor is the structural concrete, as in the balance of the apartment.

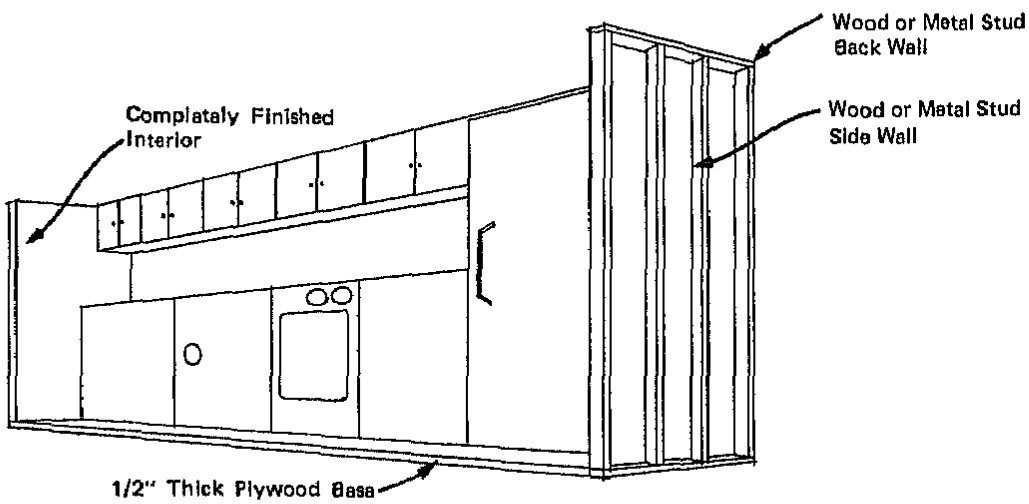
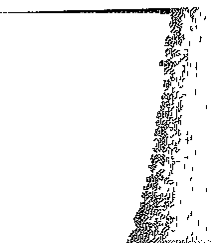


FIGURE 6.8
DESCON/CONCORDIA–KITCHEN MODULE

7.

ELECTRICAL



7.1 HIDDEN ELECTRICAL RACE-WAYS IN CONCRETE PANELS

Housing Manufacturer: BSI

This system incorporates electrical conduit cast into the factory-produced concrete panels. Flexible raceway connectors are placed at the panel joints prior to grouting to join the conduit continuously. The flexible connectors match the panel setting tolerances. Integration of mechanical elements into precast panel systems produces cost savings since fewer operations are performed in the field.

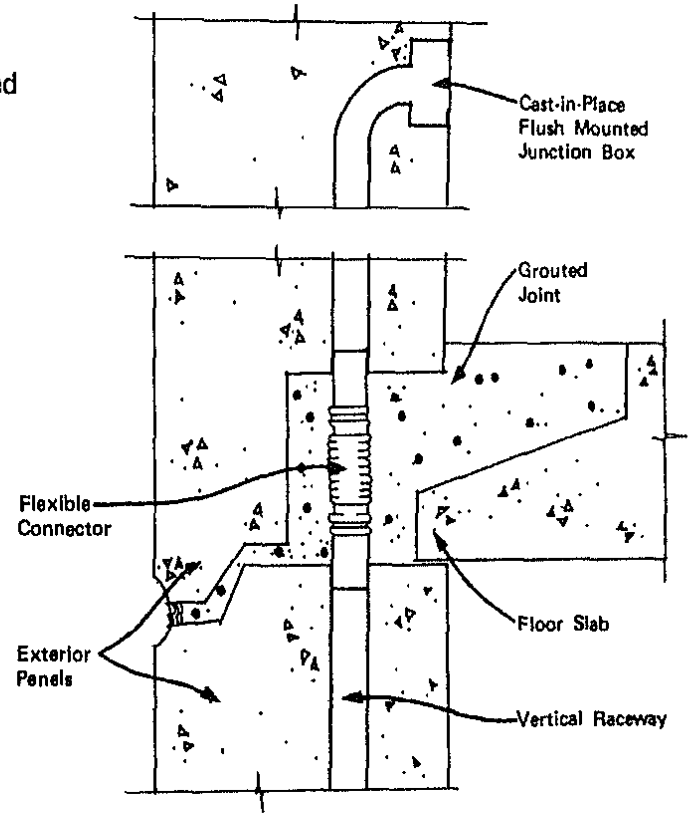


FIGURE 7.1a
TYPICAL STRAIGHT RUN CONNECTOR

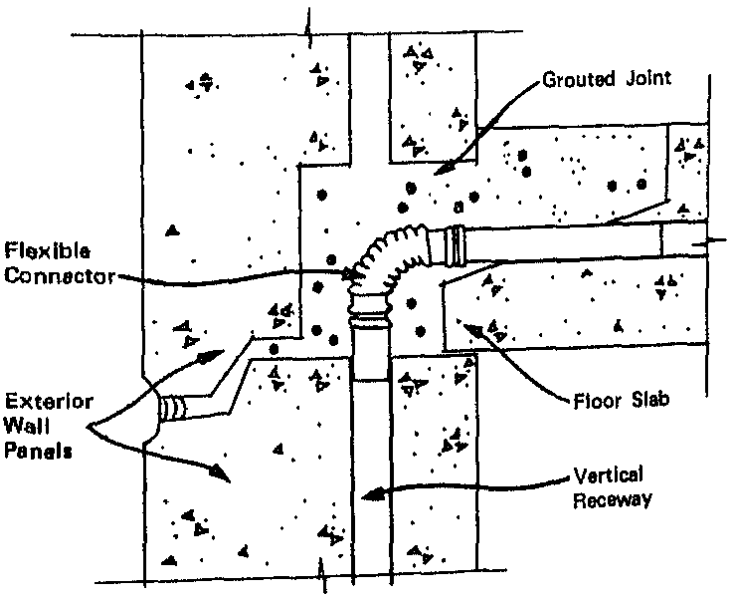


FIGURE 7.1b
TYPICAL ELBOW CONNECTOR

7.2 EXPOSED ELECTRICAL RACEWAY

Housing Manufacturer:
Descon/Concordia

A compartmented metal raceway is used in this precast concrete panel system for electrical distribution and television, telephone and communications signal distribution, Figures 7.2a and b. The raceway configuration provides separate ducts for the high voltage and low voltage wiring. The raceway is mounted to the base of the concrete wall and a conduit crossover is cast into the panel as needed to carry the wiring through intra-dwelling partitions. Crossovers are stuffed with resilient acoustic caulking to reduce sound transmission between dwellings. A continuous resilient clip at the bottom of the baseboard hides the floor-wall joint without further finishing.

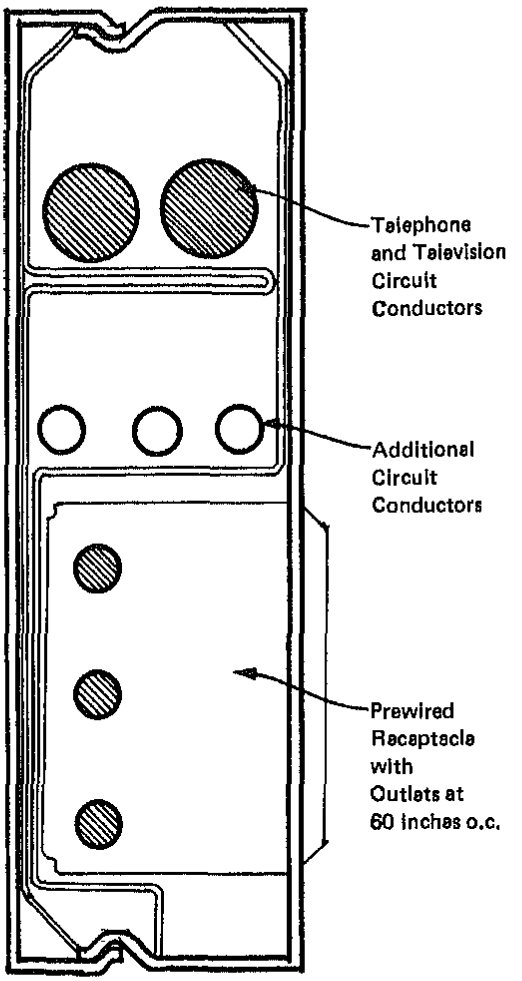
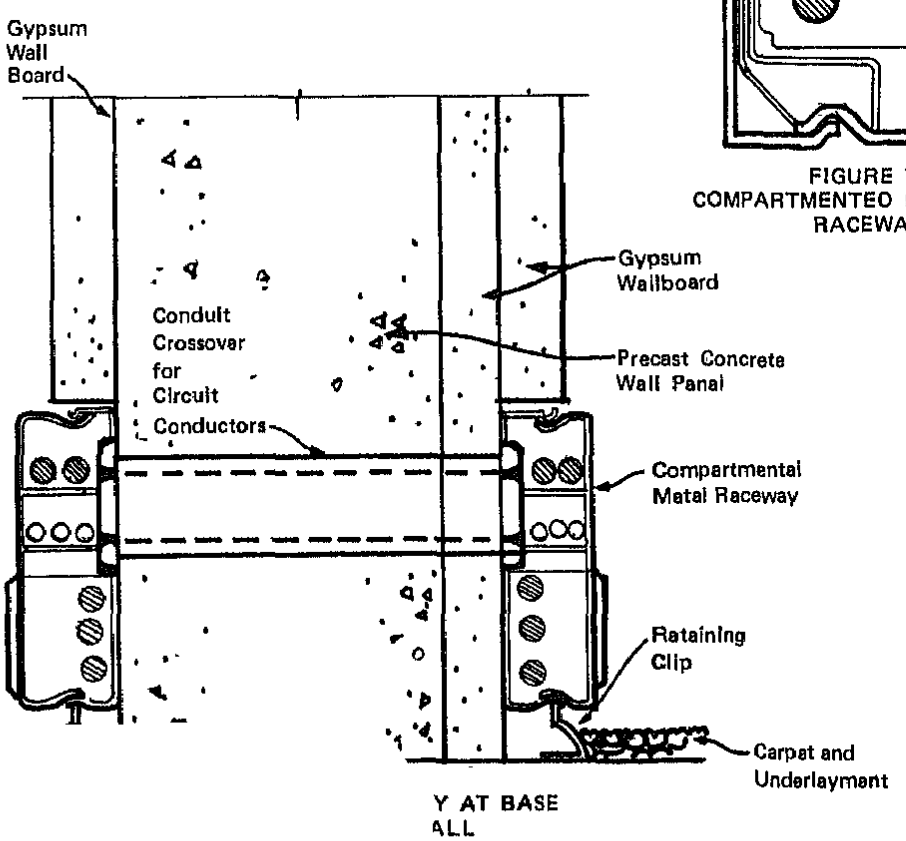


FIGURE 7.2b
COMPARTMENTED ELECTRICAL RACEWAY



Y AT BASE
ALL

7.3 SURFACE MOUNTED WIRING

Housing Manufacturer:
Republic Steel

It is difficult to install electrical wiring inside a paper honeycomb-core panel. As an alternate approach, wiring is run from the electrical raceway of the grade beam up through the channel panel joint to a switch, Figure 7.3a. After installation, the wire is covered with a plastic cover insert that fits into the recessed channel, Figure 7.3b. See 2.6 for description of the grade beam.

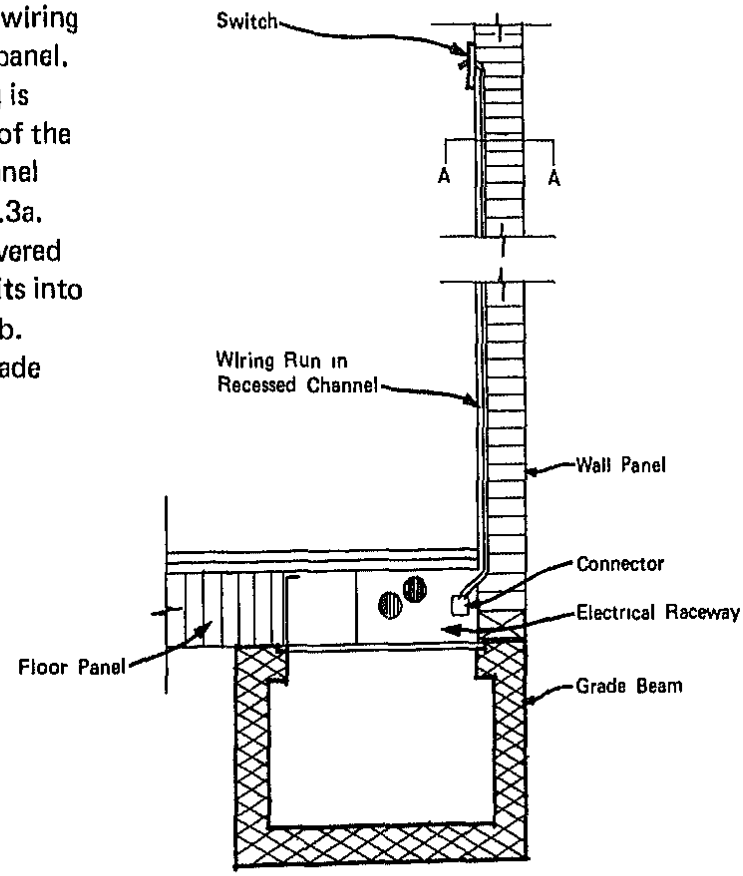


FIGURE 7.3a
SURFACE MOUNTED WIRING

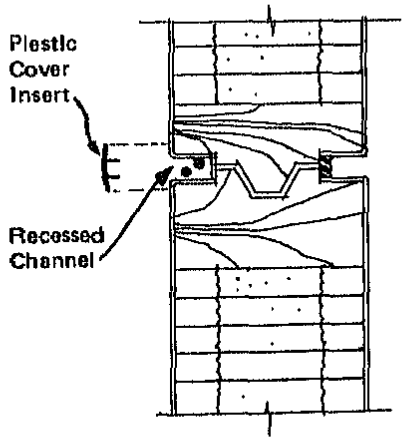


FIGURE 7.3b
SECTION A-A AT VERTICAL WALL
PANEL JOINT

7.4 PREASSEMBLED ELECTRICAL WIRING HARNESS

Housing Manufacturer:
Boise Cascade

A preassembled electrical harness is used in lieu of conventional field wiring by this system. The basic layout of the harness is an "octopus" arrangement as shown in Figure 7.4. Each harness consists of a central junction box or circuit breaker panel and a network of preterminated legs using outlets and switches specifically designed for attachment in high volume factory assembly lines.

The harness is dropped onto the module during the factory fabrication and the outlets and switches are positioned in precut holes. Switches and outlets are of a conventional design with factory terminated wiring. They are specifically designed for use in housing factory assembled by unskilled labor.

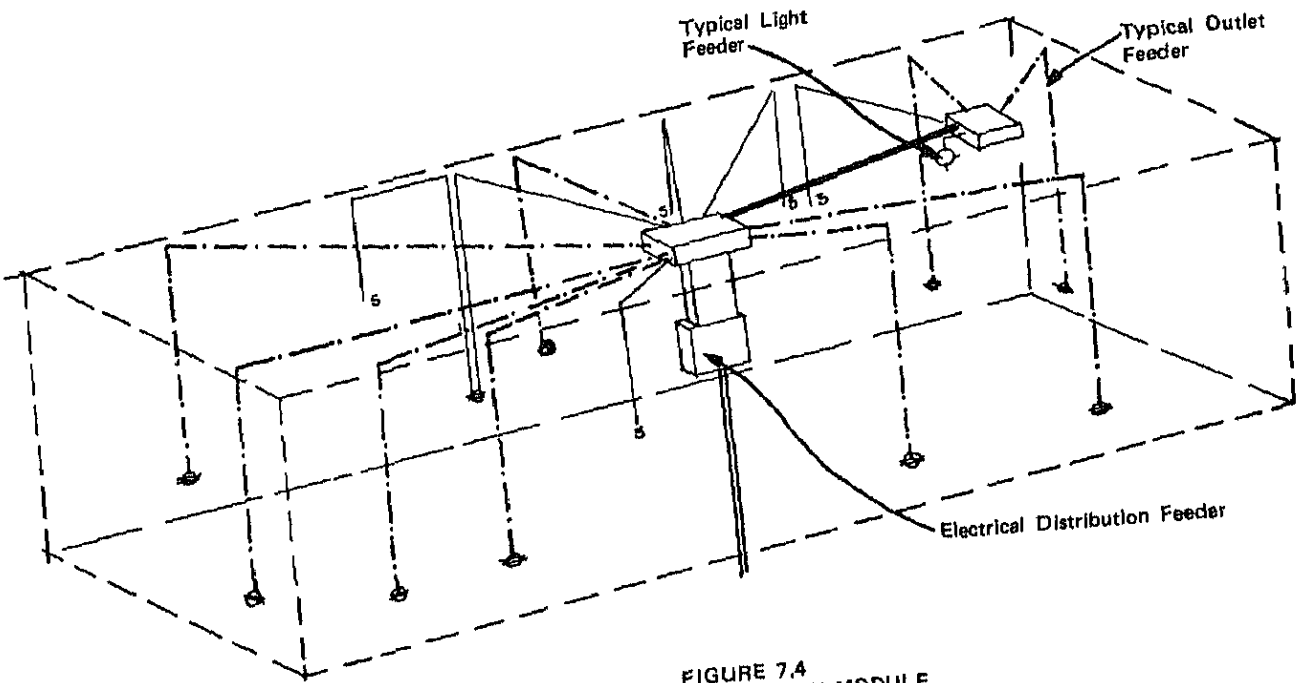


FIGURE 7.4
HARNESS INSTALLED IN MODULE

7.5 PLUG-IN ELECTRICAL CONNECTORS USED IN MODULAR UNITS

Housing Manufacturer:
Levitt

The Levitt System uses a quick connect splicing connector for use in connecting electrical circuits between modules. Connectors are installed in modules during construction. A module containing a plug is placed adjacent to a module containing a receptacle; the plug is placed into the receptacle and the circuit is completed. These connectors can be positioned at various wall locations, so that any number of circuits and outlets are available to meet any electrical wiring requirements. The connectors are coded for easy identification to prevent electrical mismating.

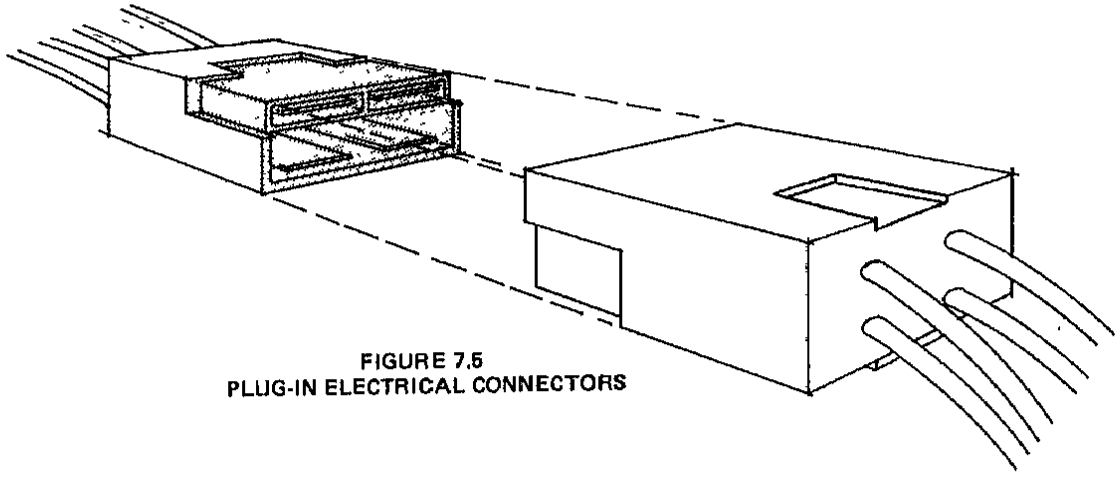


FIGURE 7.5
PLUG-IN ELECTRICAL CONNECTORS

8.

ELEVATORS

8.1 FACTORY PRODUCED PRE-CAST CONCRETE ELEVATOR MODULES

Housing Manufacturer:
FCE-Dillon

This industrialized precast concrete panel system uses a precast elevator shaft module in one-story units which are erected in sequence with the rest of the building (see 2.16). The module contains elevator rails, framed door openings, doors, call buttons and wiring, a floor indicator and positioning pins for use in erection.

The top module of the elevator shaft is a covered box to be used for cab-overrun and contains the necessary motors, support beams, pullup and control equipment. Both a single and double shaft system can be used.

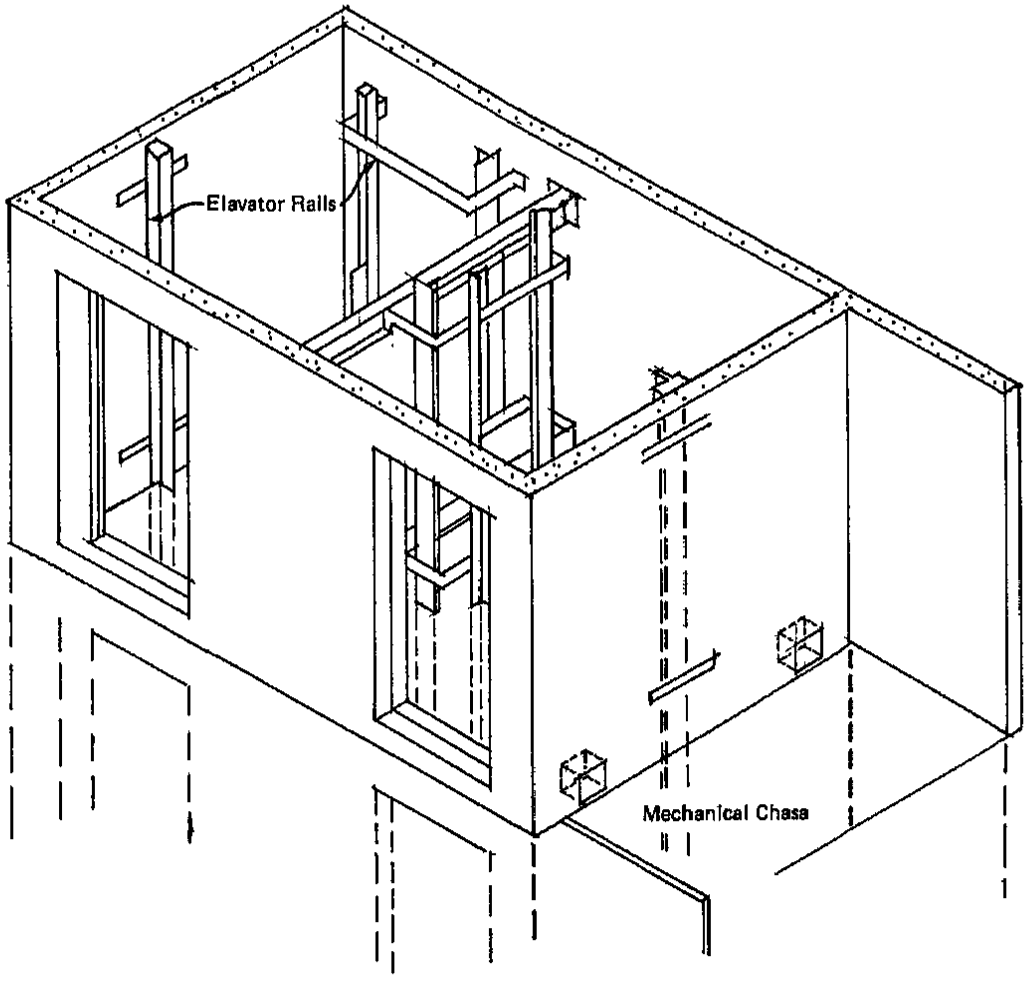


FIGURE 8.1
TYPICAL PRECAST DOUBLE ELEVATOR SECTION

9.

HARDWARE, SPECIALTIES & APPLIANCES

9.1 LOCATION OF SMOKE DETECTORS

Life safety in fire emergencies is greatly enhanced if a self-actuating alarm system is incorporated into the building design. A smoke detector is one of the most effective early warning fire detection systems. The following smoke detector location pattern was used in all Operation BREAKTHROUGH houses.

Single-Family Detached and Attached Dwellings

An automatic smoke detector is provided at the top of each interior flight of stairs in buildings greater than one story, and not having a second stairway from the upper floor, Figure 9.1a. The smoke detector is connected to a continuous sounding alarm.

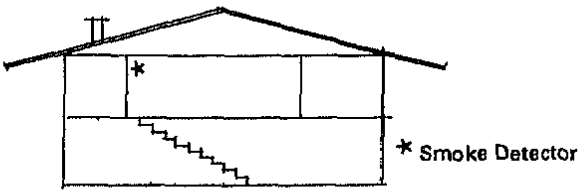


FIGURE 9.1a
LOCATION OF SMOKE DETECTOR
IN SINGLE FAMILY
DETACHED DWELLING

Multi-Family Low-Rise Dwellings

An automatic smoke detection system is provided in the corridors on every floor of buildings that have more than ten apartments per floor, Figure 9.1b. The smoke detection units are connected to continuous sounding alarm devices which are audible in every dwelling unit on each floor. The system is also capable of directly initiating an alarm over a municipal telegraph or telephonic fire alarm system.

Generally, it is recommended in the Operation BREAKTHROUGH criteria that no point in a living room be more than 50 feet from a corridor door and no living unit be more than 100 feet from an exit. This 100 feet may be increased to 150 feet if the building has a smoke detection system in a corridor connected to the alarm system. Likewise it is recommended that the dead end corridor distance should not exceed 20 feet except where an approved smoke detection system is used; then this distance may be increasad to a maximum of 40 feet.

For individual apartments on more than one level, either an exit should be provided on each level or an approved smoke detector should be installed on the stairway between the two levels.

A single exit may be permitted for two-story apartments if there are not more than four living units per floor and the travel distance from the door of the living unit to an exit does not exceed 20 feet. If an approved smoke detection system is provided, the travel distance may be increased to 40 feet.

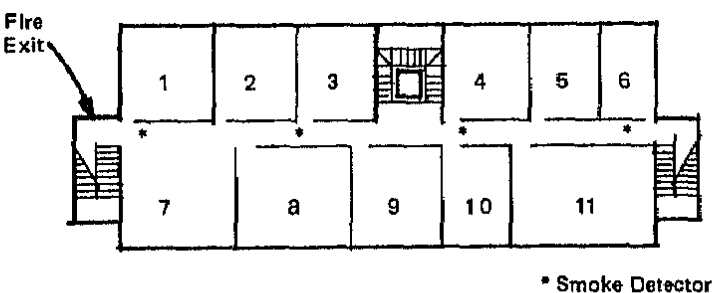


FIGURE 9.1b
TYPICAL FLOOR PLAN–MULTI-FAMILY
LOW-RISE DWELLING

9.1 LOCATION OF SMOKE DETECTORS
continued

Multi-Family High-Rise

For buildings which are seven or more stories high, manual fire alarm pull stations are provided at the entrance to each stairwell and elevator bank at each floor level, Figure 9.1c. In addition, for floors with more than ten apartments, an approved smoke detector system is provided in the corridor and tied into the alarm system. Activation of either alarm system initiates continuous sounding alarm devices (bells, horns, etc.) on the floor of activation and the floor immediately above only and indicates on the required annunciators the floor on which the alarm was initiated.

Again, no point in a living room should be more than 50 feet from a corridor door and no living unit should be more than 100 feet from an exit. This 100 feet may be increased to 150 feet if the building has a smoke detection system in a corridor connected to the alarm system. The dead end corridor distance should not exceed 20 feet except where an approved smoke detection system is used; then this distance may be increased to a maximum of 40 feet.

For individual apartments on more than one level, either an exit should be provided on each level or an approved smoke detector should be installed on the stairway between the two levels.

Housing For the Elderly

Smoke detectors are spaced at 30 feet on center in every corridor and are tied into the alarm system. They automatically close held-open horizontal smoke barrier doors. The smoke detectors should deactivate the elevators in accordance with the ANSI appendix to the Elevator Code. Smoke detectors are required in addition to horizontal exits at every floor and stairways designed as smokeproof towers.

Other recommendations listed under multi-family low-rise and multi-family high-rise should be followed when applicable.

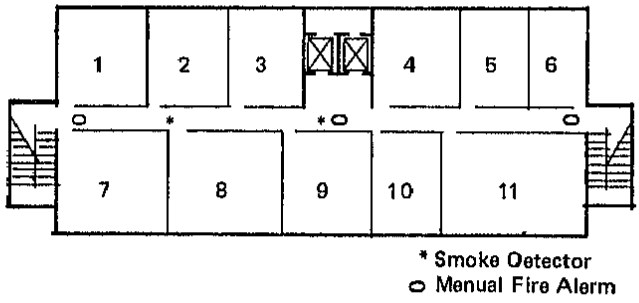


FIGURE 9.1c
TYPICAL FLOOR PLAN–MULTI-FAMILY HIGH-RISE

9.2 CHASE SPRINKLER MEETS FIRE REQUIREMENTS

Housing Manufacturer:
Descon/Concordia

The Descon/Concordia system uses a lightweight, prefabricated, plumbing, ventilation and electrical service chase placed floor-to-floor adjacent to the bathroom and kitchen modules, Figure 9.2. In order to provide the equivalent of a 1 hour fire endurance for the chase, a sprinkler head is added to a cold water line below the floor slab plug which is built into the service chase. The units are linked vertically utilizing speed connectors.

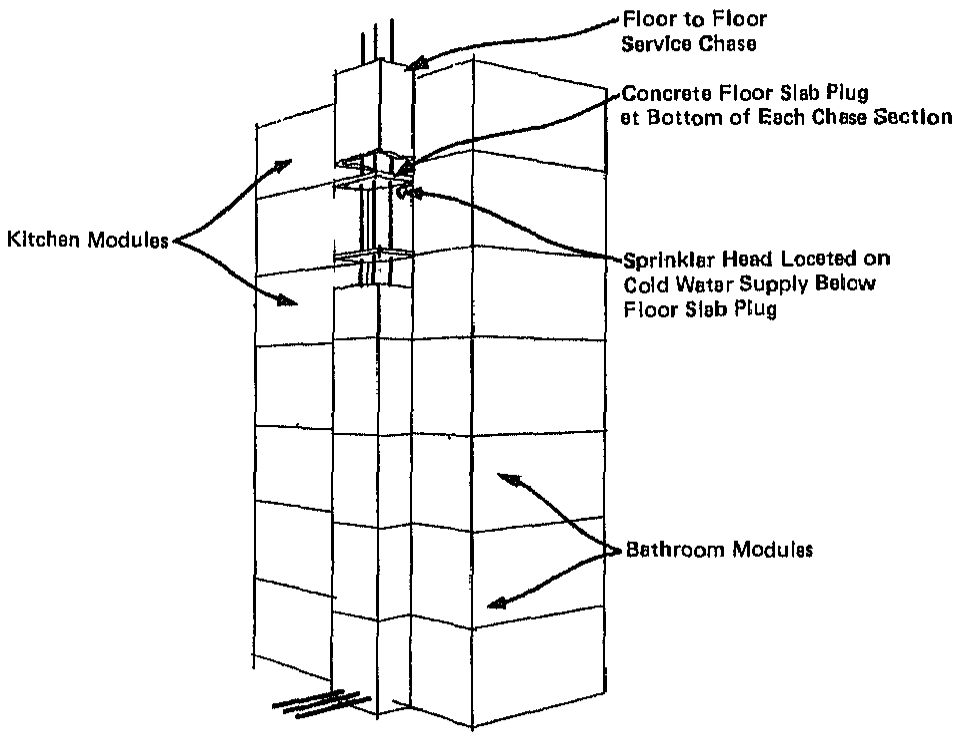


FIGURE 9.2
SERVICE CHASE ADJACENT TO BATH
AND KITCHEN MODULES

9.3 ROOF DRAINS HIDDEN IN STRUCTURE

Housing Manufacturers:

Levitt

BSI

To avoid attaching rain carrying equipment to the facade of a dwelling, Levitt drops the downspouts through the mechanical chase in the middle of the building to the crawl space when the water is then directed to either storm sewer or the yard, Figure 9.3a.

Building Systems International's high-rise, precast concrete panel system incorporates "mini-drains" in some wall panel joints, Figure 9.3b. Their primary purpose is to carry away rain driven into the joint and are in addition to the regular roof drain system.

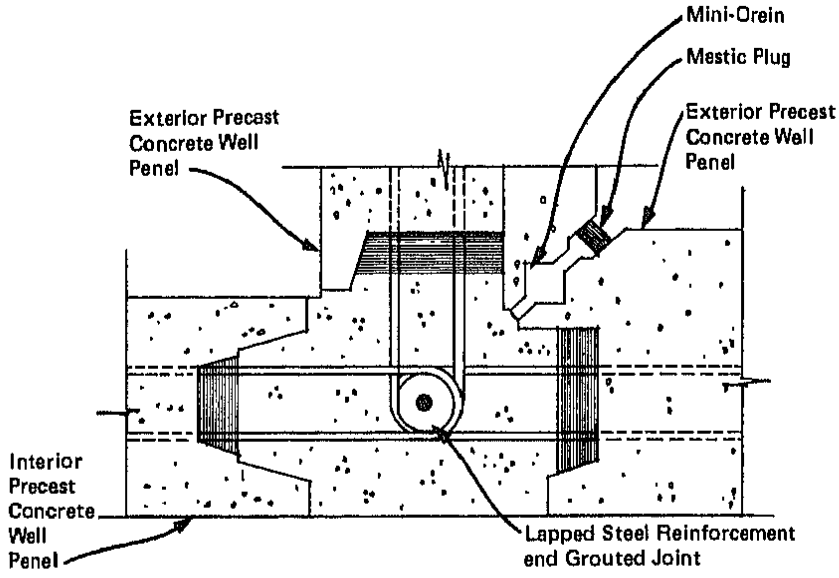


FIGURE 9.3a
BSI–MINI-DRAIN AT VERTICAL WALL PANEL JOINT

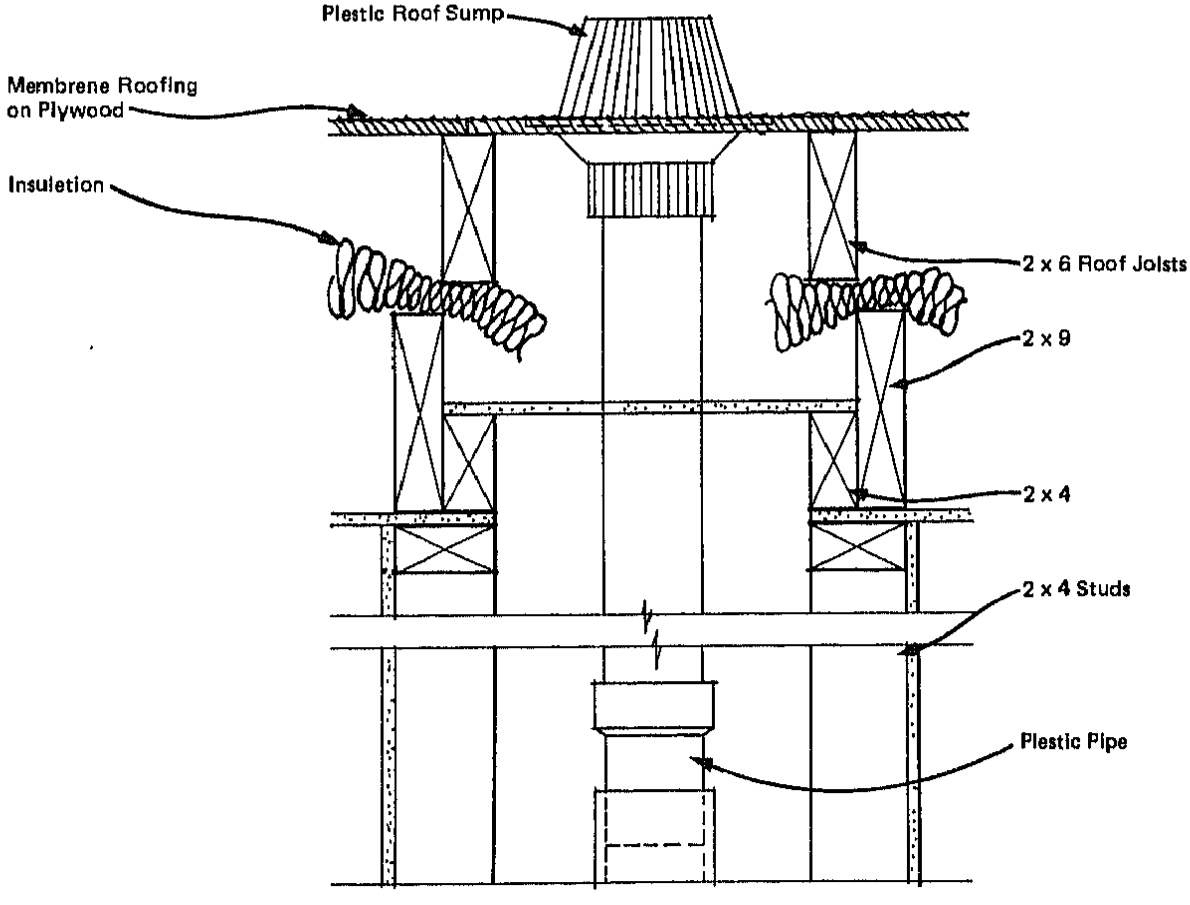


FIGURE 9.3a
LEVITT–PLASTIC DOWNSPOUT IN MECHANICAL CHASE

9.4 HIGH-RISE PLUMBING SYSTEMS UTILIZE PLASTIC PIPE

Housing Manufacturers:

Rouse-Wates

Shelley

P.V.C. plastic soilwater and rainwater pipe and C.P.V.C. hot and cold water supply are used in the Rouse-Wates high-rise systems. Advantages over more conventional piping systems include less expensive material, lighter weight and simplified joining techniques. The plastic pipe is used in a single stack drain waste and vent plumbing system.

C.P.V.C. hot and cold water supply are used in the Shelley system.

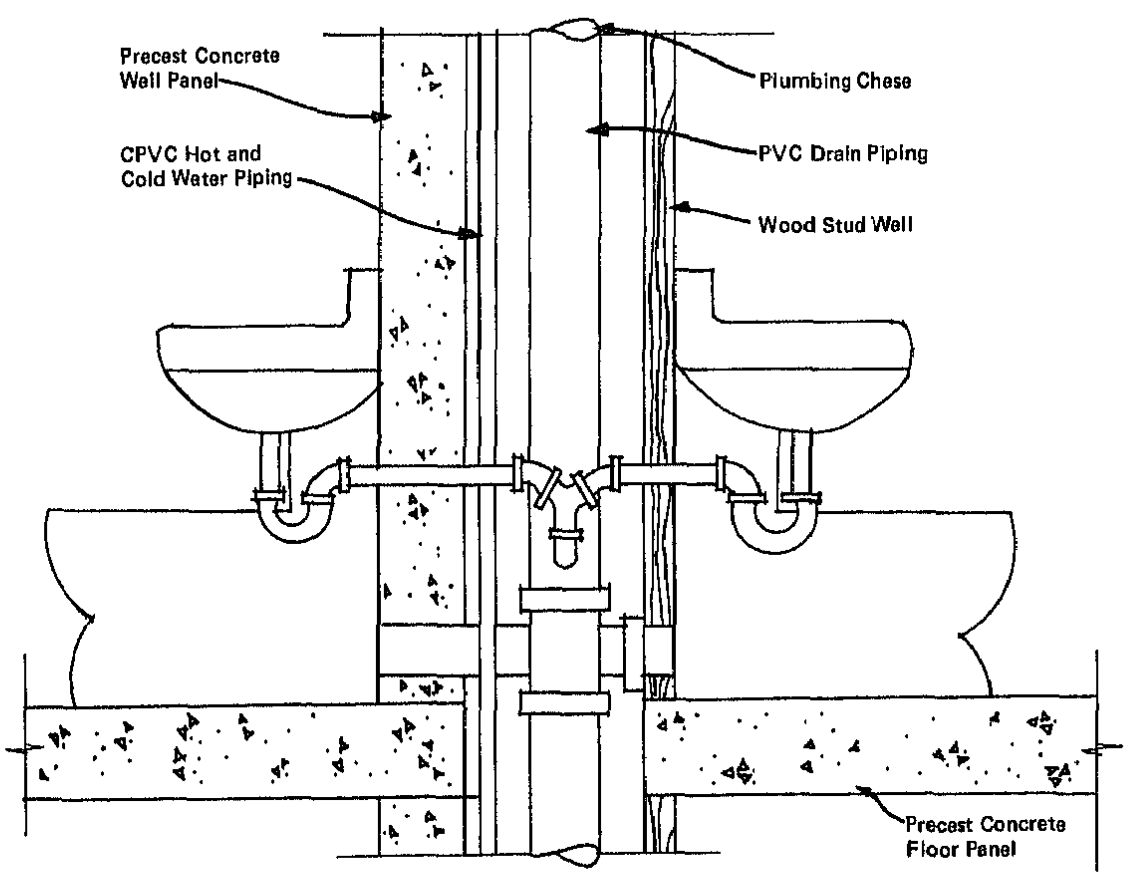


FIGURE 9.4
TYPICAL PLUMBING CHASE UTILIZING PLASTIC PIPE

9.5 PORTABLE OCCUPANT SECURITY SYSTEM

SITE: Sacramento, California

An emergency security system for the protection of the elderly is being tested at the Operation BREAK-THROUGH Site at Sacramento, California. Each occupant carries a pencil like device which in case of accident, sudden illness, or other threats to safety can be used to alert a control panel which is manned around the clock.

Each dwelling unit has three sensors which can pick up signals from the device. At the press of a buttom on the device, the sensor flashes an alert to the panel which pinpoints the location where help is needed. Immediate contact can be made with the occupant and required emergency help summoned.

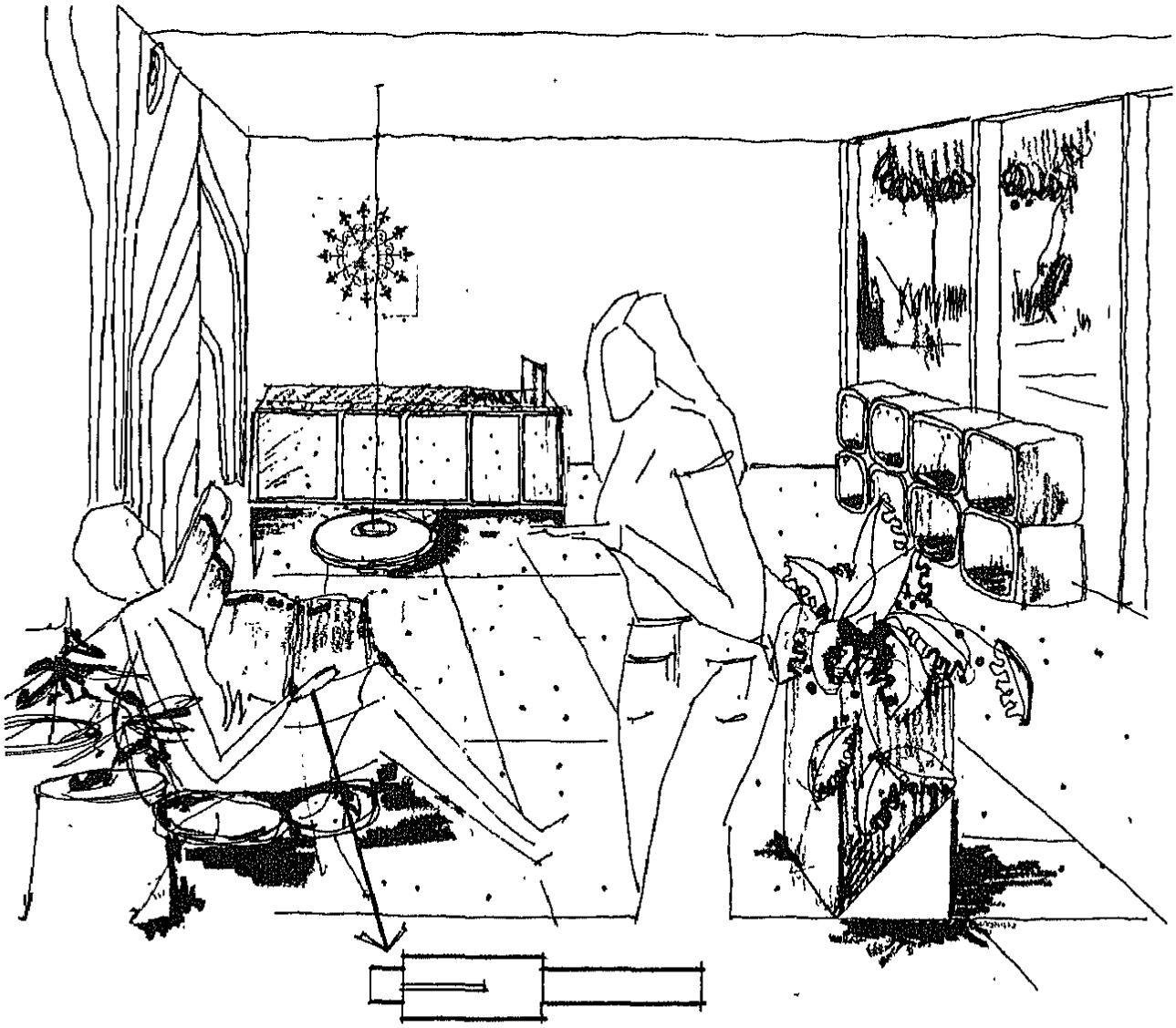


FIGURE 9.5
PORTABLE OCCUPANT SECURITY SYSTEM

HOUSING SYSTEMS PRODUCERS

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Building Systems International Macon, Georgia	Building Systems International 1415 Peachtree Center 230 Peachtree Street N.W. Atlanta, Georgia 30303 Chip Hutchison; Larry Wilson (404) 577 - 7650
CAMCI Jersey City, New Jersey	CAMCI 320 W. Fordham Road Bronx, New York 10453 Paul R. Sussman, Program Manager (212) 932 - 0444 or 751 - 3100
Christiana Westarn Sacramento, California Macon, Georgia King County, Washington	Christiana Western Structures 3025 Olympic Boulevard Santa Monica, California 90404 Daryl Rowe (213) 829 - 2956
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acknowledgements

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